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CHEMICAL.

As in the three years previous to 1935, investigations into he influence of such factors as manuring, plucking and jat of ush on the value of the made tea, have formed the most im- ortant part of the work of the department during the past year.

These investigations, taken in conjunction with previous ork on the subject of the quality of tea, provide considerable vidence in support of the hypothesis put forward by the Botanist o the effect that "quality is associated with xeromorphic rowth." This latter is defined as that type of growth conse- uent on structural changes resulting from loss of water by the plant, or restricted supply of water to the developing leaves. Conditions for xeromorphic growth occur especially during the second flush and autumnal periods, when quality teas are made.

Three factors inducing the opposite of xeromorphic condi- tions, *i.e.*, increased water supply to the growing tissues, may he expected to be—

(1) heavy nitrogenous manuring

(2) potash manuring

(3) removal of older wood, i.e., causing new growth to commence from a point closer to the root system.

These three operations all tend, to a greater or lesser extent, o reduce quality.

There is a very slight tendency for phosphate manuring to educe the moisture supply to the young leaves, and a similar ery slight tendency towards increased quality from phosphoric cid manuring at Tocklai. The plucking of top pruned bushes ver a long length of new wood might be expected to produce more eromorphic growth in the shoots than plucking close to the prun- ng level. Experiments on the relative quality of tea from these styles of plucking show that significantly better valuations result, during the autumnal period, from the former type of plucking. This experiment must be repeated for other seasons before any final conclusion can be reached.

Banjhiness is also likely to be associated with xeromorphic growth. On several occasions banjhi leaf has been manufactured and the resulting teas compared with teas from normally flushing shoots. Reports show that a distinct flavour is apparent on the teas from banjhi growth which is not apparent on the ordinary tea. A coarse character, combined with thin liquoring qualities, however, generally more than offsets the flavour, and on the whole except during the autumnal period, banjhi leaf makes poorer tea than that from normally grown leaf.

Before the manufacturing season commenced, investigations on the errors of sampling of teas, weighments into cups, infusion and tasting of samples were made.

During the Second Flush period, manuring and fineness of plucking were under investigation; during the Rains period, jat; whilst during the Autumnal period, the effect on quality of leaving different lengths of growth in plucking, was studied.

Throughout the months of August, September, October and November, experiments were carried out on the firing of tea, including the effect of different firing temperatures on keeping quality.

As in previous years all experiments were replicated and were designed in such a way that the effects of factors other than the particular one under investigation, could be determined. In all experiments the valuations of 5 or more Calcutta, and 4 or more London tasters were obtained.

One experiment, carried out on an estate in the Dunseri district of Assam, was concerned with the effect of phosphoric acid on quality.

Analyses of the tannin, caffeine, soluble matter, potash, phosphoric acid and nitrogen were made on teas manufactured during the Second Flush period, in connection with the effect of manuring on quality.

The effect of manuring, and of different degrees of fineness of plucking on the moisture content of green leaf, was investigated at Borbhetta.

A comparison of the tannin content of tea liquor with that of betelnut, pan leaf and catechu has been made, and the results are of considerable interest in connection with the campaign on the sale of tea in India.

Work on soil acidity, and analysis of soils, manures, water samples, etc., was mainly of a routine nature. Throughout the year analyses of compost samples and of raw materials for composting, sent from various gardens in North-East India, were made. During June, July and August, weekly determinations were made on the nitrate content of soils from plots at Borbhetta where trials of green manuring are in progress.

Analyses of nitrogen, potash, phosphoric acid, moisture, and ash in tea prunings from 16 plots of top pruned tea at Borbhetta were made at the end of the year.

The following is a detailed account of the work done during 1935.

I. ERRORS CONCERNED WITH THE DETERMINATION OF THE VALUE OF TEAS.

A sample of tea obtained from experimental manufacture at Tocklai is normally of about 5 lbs. in weight, after sorting. From this sample up to 12 small 2 ounce samples have to be taken for valuation by the different tasters.

Taster's infusions are made by weighing out 2.8 grams (the weight of a silver 4-anna, or six-penny piece) of tea, in a small balance. This tea is placed in a porcelain or China cup which is filled with boiling water, and after 5 minutes the liquor is strained off into a tasting bowl. If an ordinary kettle is used, only the first pot gets properly boiling water, while if 8 or 10 infusions are made, the last two or three will have water which is considerably off the boil.

The following table shows the drop in temperature of water poured into 9 successive pots.

No. of pot.	Temperature in °F. of water		
	immediately after pouring in.	after 5 mins.	
1	201	167	
2	201	163	Water boils at 212°F.
3	198	163	
4	194	165	
5	194	163	
6	196	163	
7	192	163	
8	187	159	
9	186	158	

The effect of the lower temperature of water used for infusing the later samples has the effect of reducing slightly the quantity of substances extracted from the tea, thus producing thinner liquors. The amount of soluble matter extracted in the earlier infused samples is higher than that of the samples later infused, as the following table shows.

No. of pot.	Average of pairs of infusions.
	soluble solids extracted, expressed as a percentage on dry tea.
	%
1 and 2	34·5
3 „ 4	34·4
6 „ 7	33·2
8 „ 9	32.2

It is unlikely, providing the addition of water is done quickly, that any appreciable difference in the liquors will result between

first and last infused teas if the number of samples is limited to 4. By using an electric kettle, the water can, of course, be kept boiling however many samples are to be infused.

The volume of a pot is subject to considerable variation. In a dozen apparently similar pots, volumes varied between 137 and 160 c.c. when filled to the brim. A liquor made in the small pot may therefore be more than 10% stronger than a liquor made from the same tea in the largest pot.

As far as the weighment of the tea into the pot is concerned, this, if done carefully on a good balance of the type normally used by tasters' is liable to very little error. 12 weighments were made by a taster on his own scales, and were checked on an accurate balance. The maximum difference in his weighings, *i.e.*, between highest and lowest weights was 0.070 grams with an average of 2.811 grams. This represents sufficiently good accuracy of weighment.

The influence of variation in size of pot and order of infusion on the strength of infusion were investigated, with the assistance of a tea taster, in the following two experiments. Five pots of similar make, but varying in volume from 139 to 160 c.c. were chosen, and labelled A to E. A bulk of about 4 ozs. of tea was taken and all infusions were made from this bulk. Weighments were made accurately on a chemical balance.

Five infusions of the tea were made and after being tasted and valued, a second set of 5 infusions of the same tea were prepared, arranging the pots in a different order. Altogether 5 sets of five infusions were made, varying the order of the pots each time. Pots were filled up with water starting from the right hand side on every occasion.

The taster was allowed to think he was valuing different teas.

The following table gives the arrangement of the pots and the valuations given to the resulting liquors.

Valuations in annas and pies.

Batch No.	Order of adding water					Average valuation of each batch.
	1st.	2nd.	3rd.	4th.	5th.	
1.	E 13/5	C 13/4	A 13/6	B 13/2	D 13/0	13/3·4
2.	C 13/2	D 13/0	E 13/6	A 13/4	B 13/5	13/3·4
3.	B 13/3	A 13/5	D 13/4	C 13/2	E 13/0	13/2·8
4.	A 13/6	E 13/5	B 13/2	D 13/0	C 13/3	13/3·2
5.	D 13/5	B 13/4	C 13/6	E 13/2	A 13/3	13/4·0
Average valuation ...	13/4·2	13/3·6	13/4·8	13/2·0	13/2·2	13/3·36

The average valuations for each size of pot are :—

pot mark	capacity cc.	valuation as. pies.
A	139	13/4·8
B	146	13/3·2
C	147	13/3·4
D	145	13/1·8
E	160	13/3·6

Standard error of a single tasting = 1·7 pies.

There are no significant differences due to size of pot or to order of infusion.

A second experiment was carried out on the same lines, but in this case 6 infusions of the same tea were made in 6 successive batches. The results showed, as in the first experiment, no significant difference due to size of pots or order of infusing. There is however just a suggestion of falling off in value of the liquors from the pots which were filled up last and last but one, *i.e.*, when the water in the kettle had cooled.

There is a possibility of error in the taking of small samples of teas from the main bulk for sending to the different tasters in Calcutta and London. Two experiments were carried out with the object of determining the magnitude of the error due to sampling and also the degree of accuracy of the valuing process of the taster.

Experiment I.--Four bulks of different tea were taken. These are designated P, Q, R and S. From each of the bulks, four samples were taken and designated.

	Sub sample.			
Bulk sample P	Pa	Pb	Pc	Pd
,, ,, Q	Qa	Qb	Qc	Qd
,, ,, R	Ra	Rb	Rc	Rd
,, ,, S	Sa	Sb	Sc	Sd

Sub samples from each of these 16 samples were sent to each of five tasters, who were asked to taste in four batches. No taster knew that he was tasting the same tea four times.

	Sample marked.	representing sub sample.
First batch.	1a	Pa
	2a	Ra
	3a	Sa
	4a	Qa
Second batch.	1b	Sb
	2b	Pb
	3b	Qb
	4a	Rb
Third batch.	1c	Rc
	2c	Qc
	3c	Pc
	4c	Sc
Fourth batch	1d	Qd
	2d	Sd
	3d	Rd
	4d	Pd

Differences between samples of the same tea.

Valuations in annas and pies.

Sample	Taster					Average per sample.	
	A	B	C	D	E		
Tea designated as P.							
a ...	9-6	8-11	8-9	9-0	9-0	9-0·4	
b ...	9-6	8-10	8-9	9-3	8-10	9-0·4	
c ...	9-4	9-0	9-0	9-3	8-10	9-1·25	
d ...	9-4	9-0	9-0	8-10	8-10	9-0	
average per taster	9-5	8-11·1	8-10·5	9-1	8-10·5	9-0·51	= average valuation of tea P.
Tea designated as Q.							
a ...	9-3	8-9	8-11	8-10	9-2	8-11·8	
b ...	8-9	8-8	8-10	9-0	9-0	8-10·2	
c ...	9-2	8-10	8-10	9-0	8-10	8-11·2	
d ...	9-0	8-8	8-11	9-3	9-0	8-11·6	
average per taster	9-0·5	8-8·75	8-10·5	9-0·25	9-0	8-11·2	= average valuation of Q.
Tea designated as R.							
a ...	8-9	8-8	8-10	9-3	9-0	8-10·8	
b ...	9-3	8-9	9-0	8-10	9-0	8-11·5	
c ...	9-6	8-11	8-9	9-0	8-10	9-0	
d ...	9-5	8-10	8-10	8-11	8-10	8-11·6	
average per taster	9-2·75	8-9·5	8-10·25	9-0	8-11	8-11·47	= average valuation of tea R.

Tea designated as S.

a ...	9-2	9-0	9-0	9-0	9-1	9-0·6	
b ...	9-2	8-9	8-11	9-0	8-10	8-11·2	
c ...	9-3	8-9	8-11	9-0	8-10	8-11·4	
d ...	9-6	8-10	8-9	9-0	8-9	8-11·6	
average per taster	9-3·25	8-10	8-10·75	9-0	8-10·75	8-11·7	=average valuation of tea S.

As far as determination of sampling error goes, there is no ndication of anything very unsatisfactory in the sampling, ince the biggest difference between average valuations of differnt samples of the same tea is 1.6 pies; *i.e.*, Q(*a*) against Q(*b*). n this case taster "A" appears to have made a mistake in giving sample Q(*b*) an unduly low valuation, on the standard which e was adopting. But of the other four tasters three do prefer ample Q(*a*) to Q(*b*). Some slight difference between sample Q(*a*) and Q(*b*) therefore might have been suspected, if we had nly the valuations of these two teas to compare. The difference f 1.6 pies, however, is not significant within the error of the xperiment so that we cannot consider these two samples to have een really different.

The calculated error to which any single tasting is liable s 1.77 pies, and the difference between means of 5 tastings must e, on the form exhibited in these 80 valuations, over 2 pies beore any such difference can be considered significant.

The test of sampling, however, is unsatisfactory since all our teas have proved to be exactly equal in value, within experiiental error. All were first flush B.O.P.'s from the Jorhat listrict.

The two teas P and Q were actually the "B.O.P." and 'B.O.P. No. 1" from the same invoice.

Last season these two grades from this garden sold consistently at about 3*d*. difference, and it had been hoped that these two teas at least would prove different, and so cause the test to be of value. In this particular invoice of first flush tea with very little tip, the two grades clearly differ very little in value.

Three of the five tasters do prefer the "B.O.P." to the "B.O.P. No. 1" one making a definite difference, the fourth makes them exactly equal, and the fifth prefers the "B.O.P. No. 1" to the "B.O.P".

Average valuations.

	Tasters				
	A	B	C	D	E
P "B. O. P"	9-5·0	8-11·1	9-1	8-10·5	8-10·5
Q "B. O. P. No. 1"	9-0·5	8-8·75	9-0·25	8-10·5	9-0

All, except A, however, agree that there is not much difference in value between the two grades.

Experiment II.—As the differences between the four teas chosen for the first experiment were so much smaller than was anticipated, a second experiment on exactly similar lines, but using four teas with greater differences, was done.

There were again 4 bulks of different tea, designated respectively P, Q, R and S.

From each of these bulks 4 samples were taken, designated respectively—

Pa,	Pb,	Pc,	Pd.
Qa,	Qb,	Qc,	Qd.
Ra,	Rb,	Rc,	Rd.
Sa,	Sb,	Sc,	Sd.

From each of these 16 samples, 6 sub-samples were taken for sending to each of 6 different tasters.

	Sample marked.	Representing.
First batch	1a	Pa
	2a	Ra
	3a	Sa
	4a	Qa
Second batch	1b	Sb
	2b	Pb
	3b	Qb
	4b	Rb
Third batch	1c	Rc
	2c	Qc
	3c	Pc
	4c	Sc
Fourth batch	1d	Qd
	2d	Sd
	3d	Rd
	4d	Pd

When forwarding samples, the tasters were asked simply to compare the four samples marked "a" among themselves, and similarly the "b", "c" and "d" sets of samples separately among themselves. In order to see whether the order of infusion made any difference, tasters were asked to infuse in the order 1, 2, 3, 4.

In this case in order to get 4 teas which were really different, the bulk "P" was plucked from a section of Bazaloni (light leaf Assam) bushes, by the system of fine plucking normally practised at Borbhetta; while the bulk "Q" was plucked from a section of Doolia (dark leafed Manipuri) tea, taking everything above the plucking level. Both were plucked after an interval of a week only, but the coarser system of plucking included a lot of bad leaf, and introduced stalk into the made tea.

The dark-leafed jat also made practically no tip, while the light-leaf made very tippy tea. Manufacture was the same for both.

The bulk "R" was made by mixing two parts of "P" with 1 part of "Q" and the bulk "S" was made by mixing 1 part of "P" with 2 parts of "Q".

The procedure therefore tests not only the accuracy of sampling, but also the accuracy of bulking.

Tea designated as P.

(Finely plucked light leaf Assam).

	Tasters						Average per sample
	A	B	C	D	E	F	
Sample a	10-0	13-0	13-0	12-0	13-6	12-0	12-3
,, b	10-0	13-0	12-9	12-0	13-6	12-0	12-2·5
,, c	10-0	13-0	12-6	12-0	13-3	12-0	12-1·5
,, d	10-0	13-0	13-0	12-0	13-9	12-0	12-3·5
Average per taster	10-0	13-0	12-9·75	12-0	13-6	12-0	12-2·625

Four of the six tasters agree that all four samples are identical. Taster "C" and "E" agree that there is a difference between samples "c" and "d" of ½ anna. Using the Analysis of Variance on these 24 valuations the odds against a difference of 2 pies in average valuation arising from chance error (and not from a real difference between the samples) are only 3 to 2. The differences observed between samples "c" and "d" therefore must be ascribed to chance error, either in the taking of the particular sub-samples sent to tasters "C" and "E" or in tasting.

Tea designated as Q.

(Coarsely plucked dark-leaf Manipuri).

	Tasters						Average per sample.
	A	B	C	D	E	F	
Sample a	8-2	9-0	8-6	8-0	10-0	9-0	8- 9·33
„ b	8-3	9-0	8-0	8-0	9-9	9-0	8- 9·0
„ c	8-2	9-0	8-6	8-3	10-0	9-0	8-10·17
„ d	8-2	9-0	8-5	8-3	9-9	9-0	8- 9·33
Average per taster	8-2·25	9-0	8-5·75	8-1·5	9-10·5	9-0	8- 9·46

The differences between samples are negligible.

Tea designated as R.

(2 parts P with 1 part Q).

	Tasters						Average per sample.
	A	B	C	D	E	F	
Sample a	8-9	11-0	10-9	9-6	12-3	10-6	10-5·5
„ b	8-9	11-0	10-6	9-6	12-6	10-6	10-5·5
„ c	8-9	11-0	10-6	9-6	12-6	10-6	10-5·0
„ d	8-7	11-0	10-9	9-6	12-0	10-6	10-4·67
Average per taster	8-8·5	11-0	10-7·5	9-6	12-3	10-6	10-5·14

The differences between samples are negligible.

Tea designated as S.

(1 part P with two parts Q).

	Tasters						Average per sample.
	A	B	C	D	E	F	
Sample a	8-4	10-0	9-0	9-0	11-0	10-0	9-6·67
,, b	8-2	10-0	8-11	8-6	11-0	10-0	9-5·17
,, c	8-4	10-0	8-9	8-6	11-0	10-0	9-5·17
,, d	8-4	10-0	9-0	8-3	11-0	10 0	9-5·17
Average per taster	8-3·5	10-0	8-11	8-7·5	11-0	10-0	9-5·54

Sample "a" is shown as very slightly preferable to "b", "c", or "d", but again the difference in average valuation cannot be considered to approach significance.

The analysis of variance of all the results is :—

Variance due to :		Degrees of freedom	Mean square.
Difference between the 4 teas ...	22991·61	3	7663·87
Difference between average standards adopted by tasters ...	11062·93	5	2212·59
Difference of opinion between tasters as to amount of difference between the 4 teas	1932·95	15	128·86
Difference between samples of the same tea	2·86	3	0·95
Difference due to order of infusing...	3·53	3	1·15
Residual variance or error ...	144·36	66	2·19
Total variance ...	36138·24	95	...

The differences between samples of the same tea are negligible. To determine this was the main object of the experiment.

The difference, on the whole, due to order of infusing also is negligible.

By the results of all 6 tasters the variances due to sampling and to order of infusion are negligible and may be included in the residual variance, making

residual variance = 150.75 with 72 degrees of freedom, giving a "mean square" for "error" of 2.0937 pies.

The "standard error" then is = $\sqrt{2.0937}$ pies = 1.447 pies.

This means that considering the form shown by all six tasters in this experiment, any single tasting is liable to an error of less than 1½ pies, which is very highly satisfactory.

The "standard errors" or measures of inconsistency of individual tasters were :—

Tasters.	Standard error (S.E.)	Range * pies	S. E. x 100 Range
A.	0·7 pies	22	3·18
B.	nil.	48	0·00
C.	1·23 pies	60	2·05
D.	2·2 pies	48	4·58
E.	1·6 pies	48	3·34
F.	nil.	36	0·00

* The range is the difference between the lowest and highest valuation.

All these "standard errors" are very satisfactorily low.

Perhaps a truer indication of the relative accuracy of the different tasters is given by the figure in the last column, which expresses the standard error as a percentage of the range. On this basis, next to tasters "B" and "F" whose tastings were 100% accurate, taster "C" shows the highest accuracy, tasters "A" and "E" come next and taster "D" has the least satisfactory value. All tastings however were good in this experiment.

Differences between the teas.

Each single taster placed the four teas in the same order, and (error being so low) made all the differences fully significant. Even the difference of 1 pie made by taster "A" between "R" and "S" is significant. In our experiments on manuring last year, no single taster nor the combined results of ten tasters could make any difference in the quality of the teas, whether manured to give 7 mds. per acre or 12 mds. This present experiment is a complete answer to critics who suggest that if there had been differences, they might not have been spotted by the tasters, on a flat market.

The teas used in this experiment were the whole *mals* cut up, with dust and B.P.S. (totalling 10%) taken out. Being unsorted teas they had to be valued practically on liquors alone, and it is not surprising that all tasters do not agree in their actual valuations. They all agree in making differences in the same directions and that is what is wanted.

In the estimates of the amounts of the differences agreement is not so good.

Average valuations per taster.

	Tasters.						Average of all tasters.
	A	B	C	D	E	F	
P (light leaf)	10-0	13-0	12-9·75	12-0	13-5·25	12-0	12-2·5
R (2 light 1, dark)	8-8·5	11-0	10-7·5	9-6	12-3	10-6	10-5·17
S (1 light 2 dark),	8-3·5	10-0	8-11	8-7·5	11-0	10-0	9-6·67
Q (dark leaf)	8-2·5	9-0	8-5·75	8-1·5	9-10·5	9-0	8-9·37
Average per taster	8-9·6	10·9	10-2·5	9-6·5	11-7·7	10-4·5	10-2·8

The average differences in annas and pies are:—

	Testers						Average of all tasters.
	A	B	C	D	E	F	
Between P & R.	1-3·5	2-0	2-2	2-6	1-2·5	1-6	1-9·3
Between R and S	0-5	1-0	1-10·5	0-10·5	1-3	0-6	0-11·5
Between S and Q	0-1	1-0	0-5	0-6	1-1·5	1-0	0-8·3

Taster "A" differs very greatly from his colleagues in his estimation of the price difference between "S" and "Q", and there are other differences of opinion which are significant but of less moment.

If the blend has the average value of its constituents,

Then "R" being 2 parts at 12-2.5
and 1 part at 8-9.37
should be valued at 11-0.8
Its actual average value is only 10-5.17.

and "S" being 1 part at 12-2.5
and 2 parts at 8-9.37
should be valued at 9-11
Its actual average value is only 9-5.67.

In no single case does any taster value either blend higher than the value calculated from his valuation of the constituents.

It appears certain, then, that no advantage can be hoped for from blending a good tea with a poor one.

Taster "E" values both "R" and "S" exactly at the prices calculated from his valuations of "P" and "Q".

Taster "F" similarly values "S" exactly at the figure obtained from his valuations of "P" and "Q".

In the other nine cases the average valuation of the blend is significantly less than that calculated from the valuations of the constituents.

II. MANUFACTURE AND ANALYSIS OF TEAS FROM PLOTS RECEIVING DIFFERENT MANURIAL TREATMENTS IN THE FIELD.

(a). *Effect on quality of different quantities of complete chemical manures in single and divided doses.*

Leaf from eight plot-sets of the Mesai Manipuri block of tea at Borbhetta was manufactured on ten occasions during the second flush, and early rains period, *i.e.*, 28th May to 30th July. On two occasions May 28th and June 11th, the teas manufactured were valued, but valuations were ignored. On the former date insufficiency of leaf caused the differential effects of the two rollers, to be very great and valuations obviously were affected almost entirely by this factor, whereas in later experiments, with larger samples, the difference in action of the two rollers was only slight. In the manufacture of the 11th June two of the teas were smoked and the whole day's manufacture had therefore to be discarded on this account. There were thus 8 occasions of manufacture and the manuring treatments of the plots from which the eight leaf samples were taken, were as follows :—

Table of crop valuations and analytical results of 2nd flush teas manured with different quantities of N.P.K. mixture in single and double doses.

Manufactured from May 28th to July 30th.

Plot set	Mixture supplying lbs. per acre.			How applied	Average valuations		On one hour infusion		On 5-minute infusion		Total Caffeine %	Total non-caffeine nitrogen %	Total		Yield up to 31st July 1935 in mds. tea per acre.
					Calcutta	London	Tannin %	Extract %	Tannin %	Extract %			P_2O_5 %	K_2O %	
	N.	*P.*	*K.*		*as p.*	*d.*									
1	0	0	0		10–11·1	14·43	16·29	41·92	8·56	26·64	4·27	3·25	0·961	2·39	1·67
2	40	20	20	one dose in March	10–10·6	14·28	15·72	41·32	8·75	26·97	4·28	3·32	0·987	2·38	3·09
3	80	40	40	one dose in March	10– 8·9	14·06	15·42	41·08	8·07	26·23	4·42	3·43	1·009	2·41	4·80
4	120	60	60	one dose in March	10– 7·1	13·89	15·15	41·07	8·10	26·57	4·45	3·54	1·007	2·47	5·62
5	40	20	20	two doses March and end June	10– 8·2	14·36	15·55	41·67	8·06	26·05	4·26	3·46	1·006	2·44	2·91
6	80	40	40	two doses March and end June	10– 5·5	14·08	15·16	41·30	8·44	27·14	4·30	3·47	0·995	2·44	4·33
7	120	60	60	two doses March and end June	10– 7·6	13·98	14·70	40·95	7·96	26·52	4·36	3·56	0·988	2·42	5·75
8	80	40	40	two doses March and mid-May	10– 7·6	14·05	15·45	41·14	8·11	26·39	4·35	3·47	1·064	2·42	4·55
				Significant difference (P = ·05)	0–3·0p.	0·33d.	0·60	0·65	...	...	...	0·10	...	...	...

Series	Manuring lbs. per acre.			Date of application and number of doses.
	Nitrogen	Phos: acid.	Potash	
	N	P	K	
1	0	0	0	
2	40	20	20	one, March 30th.
3	80	40	40	one, March 30th.
4	120	60	60	one, March 30th.
5	40	20	20	two, March 30th., and June 26th.
6	80	40	40	two, March 30th., and June 26th.
7	120	60	60	two, March 30th. and June 26th.
8	80	40	40	two March 30th., and May 14th.

These plots have been manured annually since 1930. The potash and phosphoric acid have been in the form of muriate or sulphate of potash, and superphosphate respectively. The nitrogen was in the form of sulphate of ammonia in 1930, 1931, 1933 and 1934, and calcium cyanamide in 1932 and 1935.

The treatments chosen were such as to enable us to compare the effect, of dividing the application of manure so that only half the total quantity applied could be in action during the second flush, with the effect obtained by applying all the manure in time for it to be available to the bush before the "quality" period.

Complete analyses were made on all teas, and valuations obtained from six tasters in India, and from four in London. A fifth London taster could not be persuaded to value the teas, but placed them each week, in order of merit.

In the following table, average valuations for London and Calcutta, crop per acre made during the period of manufacture, analyses of tannin, caffeine, soluble solids in infusions, and non-caffeine nitrogen, potash and phosphoric acid on the dry tea are given.

Effect of manuring on valuations.

There is no significant difference in valuation between the teas from unmanured plots and those which had chemical mixture in quantity to supply 40 lbs. nitrogen and 20 lbs. each of potash and phosphoric acid, either in single or divided dose, although the crop of second flush tea from the 40 lbs. application is nearly twice that from unmanured tea. The Calcutta valuations do not indicate any significant difference between teas from unmanured plots and those getting the mixture supplying 80 lbs. nitrogen in a single dose, but London tasters do significantly prefer the unmanured tea to that which had 80 lbs. nitrogen in one dose. Both London and Calcutta tasters agree in preferring the unmanured teas to teas from plots manured with 80 lbs. nitrogen in divided doses, or from plots manured with 120 lbs. nitrogen in single or divided doses. These latter teas are significantly inferior to teas from plots manured with 40 lbs. nitrogen, the normal dose used in manuring commercial tea concerns.

It is of interest to note that in no case does the delay in application of half of the total dose of manure till after it is capable of becoming available during the second flush, result in better tea.

Effect of manuring on analysis.

The 5-minute infusion analyses show no significant differences, nor any indication of a regular effect on tannin or soluble solids, due to manuring.

In the dry tea, potash and phosphoric acid analyses show no significant differences. There are however indications that the percentages of these minerals are increased in the dry tea, by use of manures supplying the appropriate mineral. Although the caffeine results do not show actually significant differences, there is a regression, both in the case of single and divided applications of manures, indicating that the caffeine content increases

with increasing manurial application. In the case of the nitrogen in the tea other than that contained in the caffeine, there is a significant increase with increasing manurial applications.

In the case of total tannin and soluble solids (extracted by boiling the tea in water for one hour), significant results are obtained. These show a decrease in tannin and soluble solids with increasing quantities of manure mixture.

The graphs showing the effect of quantity of N.P.K. mixture applied on the crop, valuations, tannin, caffeine, total soluble matter, nitrogen, potash and phosphoric acid contents of tea, are of interest, and summarise the results clearly.

The better priced teas resulting from moderate or no manuring, have the higher total tannin and total soluble solids and the lower caffeine and non-caffeine nitrogen. High caffeine content is considered to be a characteristic of high quality teas, but either this does not hold when high caffeine content is a result of intensive manuring, or possibly, any improvement in quality resulting from the increased caffeine content is not sufficient to offset lowering in quality due to change in character or quantity of other constituents consequent on heavy manuring.

In the appendix, Tables I to IV give average weekly and individual tasters' valuations (Calcutta and London) on the 8 sets of teas referred to in the foregoing experiment.

(*b*). *Effect of phosphoric acid manure on quality of tea.*

An attempt was made to determine the effect of phosphoric acid on flavour and quality, on a garden noted for good quality. The plots from which the leaf was obtained are ones on which the following manurial dressings have been given annually for 6 years.

Plot-set No.	Manures to supply lbs. per acre.			mds. tea per acre 1935.
	Nitrogen.	Phos. acid.	Potash.	
1	0	0	0	10·89
2	60	0	0	15·03
3	60	40	0	15·45
4	60	0	40	15·19
5	60	40	40	14·80

A minimum of 2 acres is required to give sufficient leaf for a roll, and as each treatment occupies only 1 acre, it was necessary to combine two treatments in each trial.

Therefore the mixed leaf from the
2 plots manured with nitrogen only
and 2 ,, ,, ,, ,, and potash
was manufactured against the mixed leaf from the
2 plots manured with nitrogen and phosphoric acid
and 2 ,, ,, ,, ,, potash, and phosphoric acid.

That is "phosphoric acid" was tried against "no phosphoric acid."

This procedure was not quite satisfactory because in the experiments at Tocklai, although nitrogen with phosphoric acid showed superiority over nitrogen only, no advantage appeared from "nitrogen with phosphoric acid *and* potash" over either nitrogen alone, or nitrogen with potash. However it was the best that could be done.

This separate manufacture was performed on eight occasions during season 1935, the leaf grown without phosphate, and that with phosphate being rolled alternately first and second.

The teas were tasted and valued by the taster whom we have always found very accurate indeed.

Only the B.O.P.'s and O.P.'s were tasted. Sorting was adjusted so that percentages were equal for both sets of tea.

The taster's valuations were in annas and pies :—

B. O. P.	Dates of Manufacture								Average
	29/6	29/7	5/8	19/8	29/8	15/9	7/10	25/10	
Without phosphoric acid ...	16-0	15-9	18-0	16-0	16-0	16-0	13-6	13-0	15/6/3
with phosphoric acid	15-6	16-0	17-0	16·6	15-9	15·6	13-3	13-1	15/4/0

The difference between treatments is not significant.

It is of passing interest to observe that this taster definitely prefers the teas rolled first.

	Dates of Manufacture								Average
	29/6	29/7	5/8	19/8	29/8	15/9	7/10	25/10	
Rolled first	16-0	16-0	18-0	16-6	16-0	15-6	13-6	13-1	15-7
Rolled second	15-6	15-9	17-0	16-0	15-9	16-0	13-3	13-0	15-3

The difference between average of order of rolling is very little more than between averages of treatments, but in this case the tea rolled first is considered the better in 7 trials of 8. The tea without phosphate is preferred only 5 times out of 8, which would be likely to occur by chance.

This observation may be taken as an indication that a cooler rolling room might show advantage.

O. P.	Dates of Manufacture								Average
	29/6	29/7	5/8	19/8	29/8	15/9	7/10	20/10	
Without phosphoric acid ...	14-6	13-0	14-3	14-0	12-6	12-3	11-0	11-6	12/10/5
with phosphoric acid	14-0	14-0	14-0	14-6	12-0	12-0	11-3	11-9	12/11/2

Here there is practically no difference between averages.

Again the teas rolled first are slightly preferred.

	Dates of Manufacture								Averages
	29/6	29/7	5/8	19/8	29/8	15/9	7/10	20/10	
Rolled first	14-6	14-0	14-3	14-6	12-6	12-0	11-0	11-9	13-0·75
Rolled second	14-0	13-0	14-0	14-0	12-0	12-3	11-3	11-6	12-9

The teas were also tasted in Calcutta, but not valued. Comparison without valuation is never satisfactory since no estimate of experimental error can be given; but it must be considered significant that on *each* occasion, the Calcutta taster preferred slightly the teas grown *without* phosphoric acid.

On the B.O.P.'s the taster who gave valuations, also slightly preferred the tea without phosphoric acid, although he did not make the difference significant.

On the basis of this experiment the use of phosphoric acid then cannot be recommended for quality on this garden, and as it makes no significant difference to crop, the conclusion cannot be avoided that the cost of its application is not justified.

III. MANUFACTURE OF TEA FROM PLOTS RECEIVING DIFFERENT PLUCKING TREATMENTS.

(a). *Effect of degree of fineness of plucking and of breaking back on quality of Second Flush tea.*

The leaf samples for this experiment were obtained from the same block of tea (Doolia dark leaf, planted 1928-29) as used for the experiment in 1934 on the effect of fineness of plucking on rains tea. In 1935 the following plucking styles were investigated each of the 8 samples being manufactured weekly for a period of 8 weeks (31st May to 19th July).

Terms applied to the style of plucking.	Type of shoots plucked and manufactured.	Details of breaking back.
1. Superfine ...	All one and a bud and all 2 and a bud and all single banjhis.	Broken back to original tipping level.
2. Fine: heavily broken back.	Large shoots of 1 and a bud, all 2 and a bud and all single banjhis.	Broken back to original tipping level.
3. Fine: broken back to janam.	As for 2.	Broken back to janam.
4. Fine: not broken back.	As for 2.	Not broken back, *i.e.* long shoots left on the bush.
5. Fine: no banjhis plucked.	Large shoots of 1 and a bud, all 2 and a bud.	Broken back to janam: banjhis left to come through.
6. Medium ...	Nothing but shoots of 2 and a bud and double banjhis.	Broken back to janam.
7. Coarse ...	Everything but one and a bud and single banjhis.	No breaking back necessary.
8. Very coarse.	Everything larger than two and a bud or single banjhis.	No breaking back necessary.

Teas were sent to 6 Calcutta and 4 London tasters; one of the latter however, did not value the teas, but placed them in order of merit.

The average valuations for the 6 tasters in India and 3 in London of the 8 replicate valuations of each tea are given in the table below, together with the crop harvested up to and including 19th July.

Style of plucking.	Crop up to July 19th in mds. tea per acre.	Average valuations	
		Calcutta as. p.	London d.
Superfine	2·24	11- 0·7	14·02
Fine : broken back to tipping level ...	2·34	10-11·7	13·68
Fine : „ „ „ janam ...	2·29	10-10·3	13·46
Fine : not broken back	2·40	10- 9·3	13·39
Fine : no banjhi leaf plucked... ...	2.34	10-10·2	13·35
Medium	2·52	10- 7·9	13·37
Coarse	3·10	9-10·3	13·08
Very coarse	3·85	8- 9·0	12·19
Significant difference (P=. 05) ...	...	0- 3·9	0·23

The Calcutta averages show the following results :—

Superfine plucking and heavy breaking back give teas which are significantly preferred to medium or the coarse forms of plucking.

There is no significant difference between the superfine, or any of the four finer forms of plucking. The two coarse pluckings give teas inferior to all others, the very coarse being inferior to the coarse plucking.

The conclusions arrived at by the London tasters differ somewhat from those of the tasters in India and are as follows :—

The superfine plucking has given teas which are regarded by the London tasters as of significantly better quality than all others. Among the four forms of fine plucking, it appears that the harder the "breaking back", the better the teas though the difference is very small indeed. The teas from the most severe form of breaking back are significantly better than those not

broken back at all, while the teas from bushes broken back to the janam occupy a position in valuation half way between the two extremes. The tea marked "Fine 4" is from bushes which were broken back to the janam (as for Fine 2) but no banjhis were plucked, being left on the bush to come through. The non-inclusion of banjhi leaf certainly has not resulted in superior teas. Medium plucking consisting of shoots of two leaves and a bud and soft double banjhis, has produced teas which the London tasters place significantly poorer than those from superfine plucking, and fine plucking heavily broken back. The medium-plucked teas are not however significantly worse than the other three styles of fine plucking.

Coarse plucked teas are significantly worse than teas from finer styles of plucking. Very coarse plucking has made much poorer teas, but nevertheless valued surprisingly well in comparison.

Average weekly valuations, and individual average for each of the London and Calcutta tasters, are given in Tables V, VI, VII and VIII of the appendix.

(*b*). *Effect of different lengths of initial growth, of leaving a big leaf, and of rains skiffing on quality of autumnal tea.*

During October and November, leaf was manufactured 6 times from plots plucked in the following ways.

Plot-set No.	Style of plucking.
1.	Tipped leaving 4″ initial growth and then plucked to the janam.
3.	„ „ 8″ „ „ „ „ „ „ „ „
4.	„ „ 4″ „ „ „ „ one big leaf left on the next round and then plucked to the janam.
6.	As for plot-set 4 but tipped at 8″ initial growth.
9.	As for plot-set 1 up to July 31st. Unplucked during August; skiffed on August 30th. leaving 3 leaves above previous plucking level and then plucked to the janam.
10.	As for plot-set 7, but skiffed leaving only one leaf above the previous plucking level.

Valuations on the teas were obtained from 5 Calcutta and 5 London tasters. The valuations given below are averages of the valuations of 5 tasters on each of 6 teas, *i.e.*, 30 valuations.

	Average valuations	
	Calcutta annas & pies	London pence.
4″ janam ...	10- 8·1	14·28
8″ ,, ...	10-11·4	14·59
4″ and leaf ...	10- 8·15	14·47
8″ and leaf ...	11- 0·5	14·69
high skiff ...	10-10·8	14·53
low skiff ...	10- 8·1	14·14
Significant difference (P=·05) .	2·4 pies.	0·33d.

The conclusions arrived at as a result of considering the Calcutta tasters' results as a whole are as follows. The leaving of a big leaf during the plucking round following the tipping has had no significant affect on quality late in the season though the tendency is for better teas to result from leaving the leaf. The extra initial growth has produced significantly better teas, whether subsequently plucked to the janam or whether a leaf was left on the round following tipping. The tea manufactured from bushes skiffed leaving 3 leaves above the previous plucking level is significantly preferred to that from bushes skiffed leaving only one leaf.

From both sets of skiffed plots, practically no leaf was plucked till October 4th, on which date and on October 11th very big flushes were taken. On these dates the teas from the *high* skiffed plots were very tippy, and were valued for their liquors significantly better than all other five. Teas from the low-skiffed plots on the contrary were worse than all the other

five. The good quality of the high-skiffed teas was not well maintained in the later pluckings.

The London valuations for 4″ and 8″ plucking (both to the janam), are not significantly different, nor are the valuations for 4″ and 8″ plucking when one big leaf is left subsequently. If however the averages for 4″ plucking are compared with the 8″ plucking, the difference becomes significant.

The combined averages for plucking to the janam as compared with those for leaving a leaf are not significant.

Average valuation	for	4″	and	janam,	and	4″	and	leaf	=	14·37d.
,,	,,	,,	8″	,,	,,	,,	8″	,, ,,	=	14·64d.
,,	,,	,,	4″	and	8″	both	to	janam	=	14·43d.
,,	,,	,,	4″ and 8″ both with a leaf left on the subsequent plucking round.						=	14·58

Significant difference = 0·23d.

The difference between the value of the tea from the high and low skiffing is significant and is in agreement with the finding of the Calcutta tasters. Thus the two sets of results generally can be considered to confirm each other satisfactorily in this experiment.

Average weekly valuations and average individual taster's valuations are given in Tables IX and X (Calcutta Tasters) and tables XI and XII London tasters.

IV. MANUFACTURE OF LEAF FROM PLOTS CARRYING DIFFERENT VARIETIES (Jats) AND PRUNED ON ONE AND TWO YEAR OLD WOOD.

Samples of leaf from 8 plots on the clearance at Tocklai were manufactured weekly from July 26th to September 13th. A brief history of this piece of tea is given below.

The block of tea consists of six different jats planted in parallel rectangular blocks (see diagram), each 250 ft. × 70 ft.

West.

B	A	B	A	B	A
K a l l i	C h i n a	K h a r i	S i n g l	B e t j a	P a n i g
n e		k a t i a	o	n	h a t
A	B	A	B	A	B

East.

As the land sloped from West to East, it was partly levelled before planting. The result of this was to increase considerably the depth of top soil along the East side and to decrease it along the West side. The tea on the East side has always done better in consequence of this, and there being a real soil difference between the two sides this might have affected quality. It is shown later that it has not done so.

Each plot is divided into two sub-plots one of which has been pruned annually since 1919, while the other has been pruned every alternate year on two-year wood, being left unpruned in intermediate years. 1935 was the year in which the biennial plots were pruned. We can therefore compare teas made from an annual pruned system with those from a biennial pruned system in a year when both were pruned.

The results do not shew whether the difference in valuation is due to different age of the pruning wood or to different length of stems as measured by height from the ground, for the annual was pruned at 30″ to 31″ and the biennial at 23″ to 24″ from the ground. It does shew that for the same number of years from

heavy pruning the biennial pruned tea is giving a poorer quality tea than that from the annual pruned in this year when both have been pruned.

For manufacture, leaf from both types of pruning of the Kalline, Singlo, Betjan and Panighat varieties was used, thus providing 8 samples which were manufactured on 8 occasions. The 8 samples were sent to each of 6 Calcutta and 4 London tasters each week.

The Calcutta averages for Jat and pruning treatment are given below :—

Jat	Pruning	Average valuation	Average of A and B
Betjan ...	Annual ...	10- 6·09	10-4·51
	Biennial ...	10- 2·94	
Singlo ...	Annual ...	9- 9·27	9-8·56
	Biennial ...	9- 7·85	
Kalline ...	Annual ...	10- 0·87	10-0·75
	Biennial ...	10- 0·63	
Panighat ...	Annual ...	10- 1·56	10-0·30
	Biennial ...	9-11·04	
Significant difference		0- 2·19 p.	0-1·55 p.

Average for 4 plots annually pruned = 10-1·45
,, ,, 4 ,, biennially ,, = 9-11·61
Significant difference :... 0-1·09p.

Jats.—Betjan gives significantly better teas than the three other jats, with the Singlo significantly the worst. There is no significant difference between Kalline and Panighat, which are dark-leafed varieties.

Pruning.—The teas from bushes pruned annually are significantly better than teas from bushes pruned biennially in the year when both are pruned.

Interaction of Jat with Pruning.—All the plots pruned annually give teas better valued than the teas from bushes of the same jat pruned biennially. Although the differences due to pruning are not the same for each jat, there is no significant interaction between jat and pruning.

Possible difference due to soil.—On each side (East and West) we have all four jats and two plots pruned annually and two plots pruned biennially. There being no interaction between jat and pruning we are at liberty to compare the quality produced by the good deep soil of the East side with that from the poorer shallower soil of the West side.

	Average valuations.
West side	... 10-0.60.
East side	... 10-0.46.

As these valuations are almost identical it must be concluded that the difference in soil has had no significant effect on quality.

In the direction transverse (*i.e.*, North to South) to that in which the effect of soil on quality is measurable, the land appears to be very even indeed, and the steady, relatively heavy manuring since all the tea was planted in 1914, has levelled out any small difference there might have been. It is important to show that little difference is likely to be caused by soil, since these old experiments are on single plots only, and if soil were affecting quality the difference due to soil would appear in the results as being due to jat.

The case of the Singlo tea is particularly interesting. It is a very light-leafed jat, but is valued lower than the two dark-leafed jats while the other light-leafed jat, Betjan is preferred to all three. Leaf-colour alone therefore is no guide to the value of tea likely to be produced. Last year the Kharikatia tea, (which is Singlo once removed) was found a good second to Tingamira, and superior (among others) to teas from the same Kalline plots as were tested this year.

We have to assume therefore on the results from Calcutta tasters only, that while the original Singlo gives tea of lower value, its daughter Kharikatia gives good tea. The two plots Singlo and Kharikatia are immediately alongside, divided only by a narrow drain, and it has been shown that difference due to soil is very unlikely. It is possible that the difference in value may be due to the fact that the Singlo plot contains a number of bushes of a character bordering on hybrid, while the selection practised when the Kharikatia seed garden was put out has almost eliminated these.

It is however at least as likely that the difference in the placing of Singlo teas in the rains, and Kharikatia teas in the autumn, is a matter of season. The autumnal Kharikatia was valued for its quality, but the thinness of its liquors was commented on. During the rains somewhat better quality was noticed in the Singlo and, as shown later, was liked by some London tasters, but this was, according to Calcutta tasters more than counterbalanced by its thinness of liquor. In the autumn the quality may outweigh the thinness.

A point of interest with regard both to Singlo and Kharikatia is that they colour less readily after rolling, than all other jats tried except Indo-China. It is possible that these jats would be better valued in Calcutta if they were to have either more severe rolling, or longer fermentation than most jats. In the experiment just described rolling and fermentation of course had to be the same for all jats, and this may have been unfavourable to the Singlo.

Three tasters in London placed valuations on the teas and one gave reports but no valuations. As there is some measure of disagreement between the different tasters, their results are considered independently.

(*a*). Taster H.

Valuations were received on all but the set manufactured on the 9th August. These teas were spoilt by contamination

during transit. The average valuations for the seven sets of teas valued, were as follows :—

Average valuations in pence per lb.

Jat.		Pruning		Average for each jat.
		Annual	Biennial	
Light leaf	Betjan ...	14·70	14·39	14·54
	Singlo ...	14·50	14·28	14·39
Dark leaf	Kalline ...	14·29	14·32	14·30
	Panighat ...	14·73	14·18	14·45
Average for each type of pruning ...		14·55	14·30	14·42

Differences between jats are not significant, but the difference in favour of annual pruning is significant, the difference being 0.25*d*. as compared with a required differences for significance on the 5% level, of 0.13*d*.

(*b*). Taster J.

Average valuations in pence per lb.

Jat		Pruning		Average for each jat.
		Annual	Biennial	
Light leaf	Betjan ...	12·58	12·61	12·60
	Singlo ...	13·75	12·86	13·30
Dark leaf	Kalline ...	12·86	12·92	12·89
	Panighat ...	12·84	12·75	12·80
Average for each type of pruning ...		13·01	12·78	12·90

Differences between *jats* and between the two types of pruning are not significant, and this is remarkable in view of the big

differences between *jats* found by the 6 Calcutta tasters, in some measure confirmed by the other two London tasters who gave valuations.

(*c*). Taster K.

Average valuations in pence per lb.

Jat		Pruning		Average for each jat.
		Annual	Biennial	
Light leaf ...	Betjan ...	14·22	13·47	13·84
...	Singlo ...	13·66	13·41	13·53
Light leaf ...	Kalline ...	13·56	13·13	13·34
...	Panighat ...	13·91	13·56	13·73
Average for each type of pruning ...		13·84	13·39	13·61

The required significant difference between jats is 0.34*d*. and thus Betjan and Panighat jats are preferred significantly to Kalline, but not to Singlo. Again, pruning annually has produced tea significantly better than from biennial pruning. The significant difference in this case being 0.24*d*.

(*d*). Taster N.

No valuations were received from this taster, who simply placed the teas in order of preference. The final order of preference, taking the teas over the whole 8 weeks of manufacture was :—Singlo easily best; followed by Kalline, then Betjan; with Panighat last. There was very little difference between the last three varieties.

As regards pruning, a slight preference was given on the whole to the teas from the annual type of pruning.

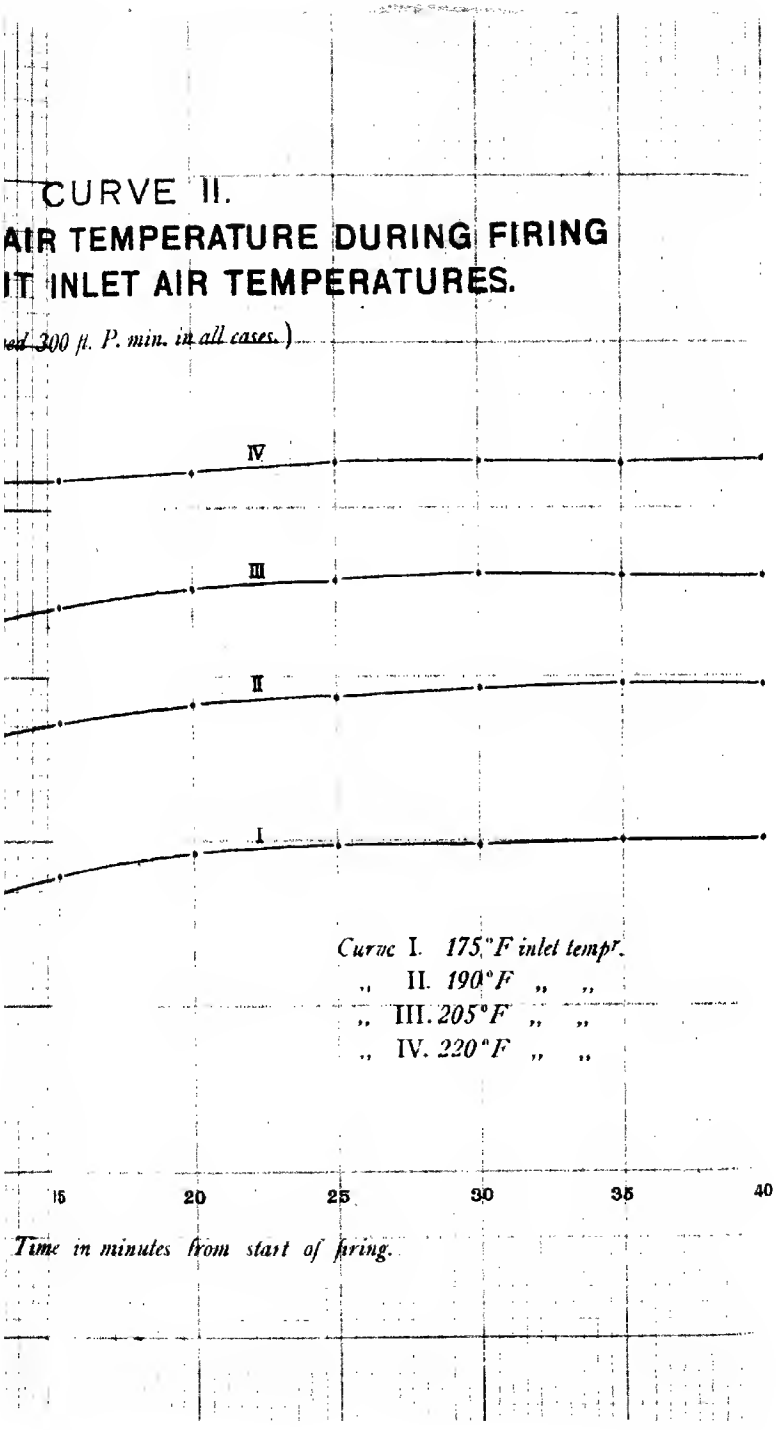
Since the results of the four tasters exhibit such opposing views regarding the relative values of teas from bushes of different jats, it would be of no value to combine the results in an

CURVE II.

AIR TEMPERATURE DURING FIRING

IT INLET AIR TEMPERATURES.

ed 300 ft. P. min. in all cases.)



attempt to obtain a general opinion. All that can be said is that the light leaf variety Betjan, though highly valued by Calcutta tasters has not received the same preference in London, while the Singlo variety, valued low by the Calcutta tasters on account of its thinness of liquor and greenness of infused leaf, is rather preferred than otherwise to the other jats by two of the London tasters. It is unfortunate that neither of the two tasters who prefer the Singlo variety have commented on the liquors or infusions. It is difficult therefore to guess the reason for this preference but the teas may possible have shown greater briskness by the time they reached London, as compared with the other varieties, and, in addition a higher value may have been placed on their quality by the London tasters.

The average weekly and individual tasters valuations for the 6 Calcutta tasters are given in Tables XIII and XIV of the appendix.

V. EXPERIMENTS ON THE FIRING OF TEA.

The dryer in use in the experimental factory is a Sirocco Single Tilting Tray machine, and firing is carried out in one operation, the teas being dried from about 65% moisture content to 3% in 40 minutes at a temperature of 185-190°F. Firing conditions are not the same as those which obtain in a factory where first firing is done in an "endless chain type of machine, the tea being dried from 65% to about 20%; and the final drying to 3% in a machine of similar type to the Sirocco Single Tilting Tray. It will therefore be understood that the results quoted below strictly apply only to the firing methods employed at Tocklai, and can only give indications of what might result in commercial practice.

(*a*). *Effect of inlet temperature of air on the teas.*

Two experiments were carried out; in the first, the teas were fired at 175°F, 190°F, 205 F and 220 F, the tea remaining in the dryer for 45 minutes in every case. Moisture determinations on the teas were made at intervals during the firing, and exhaust air temperatures were recorded at frequent intervals. These results are recorded on graphs (See appendix), and served as a

21st August. It will be understood that 12 samples were taken independently from a bulk of about 5 lbs. tea lying in a large enamelled bowl. Of these twelve samples 6 taken at random were numbered "3" and the other 6 were numbered "7". One of the samples numbered "3" and one of the samples "7" were sent to each of the six tasters.

It is somewhat disturbing to find in the teas made on August 21st, that a remarkable combination of sampling and tasting errors results in 3 being valued 4.6 pies higher than 7. Among samples 1 to 4, No. 3 is placed a good second: among the duplicate samples 5 to 8, No. 7 is placed as a bad third.

This was not due to any one bad mistake, but 5 of the 6 tasters happened purely by chance to place better the tea they tasted first.

When a result such as this can occur, when comparing averages of 6 independent tastings, the danger will be realised of relying on a single tasting of a single pair of samples from very large bulks, as is commonly done in garden experiments.

It will be observed however that when the experiment is repeated four times the final averages of the teas made by the four treatments come out closely alike, in both sets of samples.

The fact that teas fired at 190°F are valued 0.3 pies less than teas fired at 175°F among samples 1 to 4, and 1 pie higher than the teas fired at 175°F among samples 5 to 8, is of no importance. In both cases, the teas fired at 175° or 190°F are equal within experimental error, while both are significantly better than the teas fired at 220°F.

Combining the two valuations on each tea from each of six tasters, the final results are:—

	Valuations as. ps.
Teas fired at 175°F	10-6·0
" " " 190°F	10-5·7
" " " 205°F	10-3·7
" " " 220°F	9-9·0
Significant difference	0-1·40

The teas fired at 220°F were always reported as high fired and sometimes as burnt. It is interesting to observe that although the teas fired at 205°F are valued very little lower than teas fired at lower temperatures, this small difference is significant.

(c). *Effect of varying temperature and time of firing.*

The same four temperatures were used as in the first experiment, but the duration of firing was for a time judged from preliminary experiments to be just long enough to dry the teas. The temperatures and times were as follows :—

Inlet temperature.	Duration of firing.
1. 175°F.	47½ minutes
2. 190°F.	40 „
3. 205°F.	32½ „
4. 220°F.	25 „

The table below gives the average valuations of the 6 Calcutta tasters for each of the four weeks.

Average valuations of 6 tasters in annas and pies.

Temperature	Duration of firing	Dates				Average of 24 valuations
		Sept. 4th	Sept. 11th	Sept. 18th	Sept. 25th	
		Samples 1 to 4.				
175°F. ...	44½ mins	10- 4·00	10-1·83	10- 0·83	10-4·17	10-2·71
190°F. ...	40 „	10- 6·83	10-4·17	9-11·17	10-2·00	10-3·04
205°F. ...	32½ „	10- 4·33	10-1·00	9- 6·00	10-1·17	10-0·12
220°F. ...	25 „	9-10·17	9-7·17	9- 3·83	9-8·67	9-7·46
Daily average		10- 3·33	10-0·54	9- 8·46	10-1·00	10-0·33

Temperature	Duration of firing	Dates				Average of 24 valuations
		Sept. 4th	Sept. 11th	Sept. 18th	Sept. 25th	
		Sample 5 to 8				
175°F.	47½ mins.	10-5·33	10-2·83	10-0·67	10-3·83	10-3·17
190°F.	40 „	10-3·00	10-3·67	10-0·83	10-2·83	10-2·58
205°F.	32½ „	10-2·17	10-0·00	9-9·87	9-7·50	9-108·9
220°F.	25 „	9-11·00	9-7·17	9-4·17	9-6·33	9-7·17
Daily average		10-2·37	10-0·42	9-9·88	9-11·12	9-11·95

There is not very close agreement between pairs of samples. Nos. 2 and 6 of September 4th differ by 3.83 pies, Nos. 3 and 7 of September 18th by 3.87 pies, and Nos. 3 and 7 of September 25th by 5.67 pies. Again the discrepancies make no significant difference to averages when the experiment is repeated four times.

In both sets, there is no significant difference between the teas fired at 175°F and those at 190°F. Both are significantly better than the teas fired at 205°F and the latter significantly better than the high fired (220°) teas. The averages for the two sets are as follows :—

Firing temperature	Duration of firing	Averages for 48 valuations
175°F.	47½ mins	10-2·94
190°F.	40 „	10- 2·81
205°F.	32½ „	9-11·50
220°F.	25 „	9- 7·31
Significant difference		1·54 pies

Comparing these valuations with those for the previous experiment in which all teas were fired for 45 minutes, it must be concluded that though the harmful effect of high firing has to a small extent been reduced by shortening the time during which the tea is in the machine, the higher fired teas are still inferior.

In view of the significant results on these teas obtained from the Calcutta tasters it is very interesting that the London tasters do not make significant differences even between the teas fired at the lowest temperature and those fired at the highest temperature.

It was thought at the time that the lower fired teas might have gone off by the time they were tasted by the London tasters (about 4 weeks from the time of manufacture) or that the teas fired at the higher temperatures had lost their "high fired" character. The results of the "keeping" experiment however show that this was not by any means the complete explanation. It is possible that the high fired character is not apparent when teas are infused in hard London water, as it is when soft Calcutta water containing little lime, is used.

The London valuations for each of the four tasters, are given in the tables below.

EXPERIMENT (I).—*Teas fired for the same time, at different temperature.*

Firing Temperature	London tasters valuations in pence				Average
	H	J	K	L	
175°F.	14·92	12·82	14·44	14·87	14·26
190°F.	15·08	12·87	14·31	14·43	14·17
205°F.	14·58	12·59	13·94	14·63	13·93
220°F.	14·63	12·64	14·15	14·21	13·91
	14·80	12·73	14·31	14·53	14·07

EXPERIMENT (II).—*Teas fired at different temperature for times sufficiently long enough to reduce the moisture content to 3%.*

Firing Temperature	Time	Tasters				Average
		H	J	K	L	
175°F.	47½ mins.	14·97	12·60	14·34	15·79	14·42
190°F.	40 ,,	15·16	13·04	14·19	15·57	14·49
205°F.	32½ ,,	14·94	12·79	13·94	15·17	14·21
220°F.	25 ,,	14·59	12·60	13·72	15·07	13·99
		14·92	12·76	14·05	15·40	14·28

There is a tendency, in both experiments, for the teas fired at lower temperatures to be better than those fired at higher temperatures but the differences are not significant. The results tend to support the Calcutta tasters' results.

(*d*). *Effect of speed of air through the dryer.*

A third firing experiment was done during October on the effect of varying speeds of air through the dryer. Normally the fan speed of the dryer is not quite fast enough for the fine particles of tea to be blown out of the top of the dryer with the exhaust air. The speed of the air flow taken over the top tray of the dryer when empty is 500 ft. per minute. By means of a variable resistance on the electric motor running the fan, and by varying adjustment of the baffle in the fan duct, four different air speeds were obtained, the slowest being 70 ft. per minute and the fastest 500 ft. per minute. Intermediate speeds were 175 and 300 ft. per minute.

Neither the Calcutta nor the London tasters however have found any significant difference between any of the teas resulting from firing at different air speeds.

The experiment was carried out on a Tilting tray Sirocco drier and the results must be accepted as applying to that drier only.

The valuations given below are average of four valuations in each case.

Calcutta.—Valuation in annas and pies.

Air speed feet per minute	Tasters						Average
	A	B	C	D	E	F	
500	10-10	9-9·8	11-4·5	6-6·7	11-7·5	10-9·2	10-7·9
300	10-6·	89-9·8	11-3·8	9-8·0	11-7·7	10-7·5	10-7·3
175	10-10·	29-9·5	11-3·8	9-9·0	11-8·0	10-9·8	10-8·4
70	10-10·	59-10·5	11-1·5	9-8·5	11-9·8	10-8·2	10-8·2

London.—Valuations in pence per lb.

	Tasters				Average
	J	K	L	M	
500	12·44	14·06	15·44	14·06	14·00
300	12·81	14·25	15·69	13·75	14·12
175	13·00	14·44	15·81	13·19	14·11
70	13·25	14·31	15·25	13·12	13·98

(e). Effect of thickness of spreaidng of the leaf on the trays of the dryer.

During November, experiments were carried out on the effect of thickness of spreading of leaf in the dryer, on the value of the made teas. Neither London nor Calcutta tasters have found any significant difference between teas from varying thickness of spreading.

Thickness of formented leaf spread in lbs. per square yard of tray space.	Average valuations	
	Calcutta annas & pies	London pence.
3	10-11·4	14·65
6	10- 9·7	14·61
9	11- 0·3	14·63
12	10-11·3	14·77

Again the results must be accepted as applying only to the drier at Tocklai.

VI. THE KEEPING QUALITY OF TEA.

The effect of different firing temperatures on the subsequent keeping quality of tea was investigated.

Samples of tea manufactured during August and September 1935, employing different firing temperatures, were stored in glass bottles for 4 months and samples were sent to 5 Calcutta tasters and to one London taster for report and valuation. In the tables below the average valuations of the Calcutta tasters on the teas immediately after manufacture and after keeping for 4 months, are given.

(1). *Teas fired at different temperatures for the same time* (45 mins.).

Firing temperature °F	Average valuations annas and pies.	
	after manufacture	after keeping 4 months
175	10-6·0	9-5·6
190	10-5·7	9-4·8
205	10-3·7	9-6·2
220	9-9·0	9-2·5
Average ...	10-3·60	9-4·75
Significant difference (P = ·05)	0-1·40	0-2·11

The drop of about one anna appears to be due to the fall in the market for rains tea. One broker remarked, "when considering the above valuations it should be borne in mind that rates have possibly undergone some change since the original samples were tasted in August."

The 220°F fired sample is still significantly poorer than teas fired at lower temperatures, and from the reports, it appears that the high fired character had not disappeared altogether on keeping, though it had become considerably less pronounced. The touch of high fire on the 205°F fired teas has apparently gone altogether, as none of the kept samples fired at this temperature, were commented on by any of the tasters as being high fired or bakey. They are moreover valued higher than the teas fired at 175°F or 190°F, but the difference is small and not significant.

The London taster (L), who valued these teas, in the first instance about 4 weeks after manufacture, and again after keeping for 4 months, does not indicate any differences which are

significant on the 20 to 1 level of statistical significance, though in both cases, *i.e.*, before and after keeping, his average valuations for the low fired teas are highest, and the high fired teas are valued lowest. The average valuations for the teas before and after keeping are as follows.

Firing temperature	average valuations in pence.	
	after manufacture	after keeping 4 months
175°F.	14·87	14·31
190°F.	14·43	14·34
205°F.	14·63	13·97
220°F.	14·21	13·75

The differences of 0.66*d*. between the high and low fired teas before they had been kept, and of 0.56*d*. between the same teas after keeping, seem large although not significant; but it must be remembered that these are averages of 4 sets of valuations, and it is worth while to examine these individual valuations, since they explain why such big differences in the averages do not pass the statistical standard of significance required.

Valuations of 170°F and 220°F fired teas.

(*a*). *After manufacture.*

Firing Temperature	Dates of manufacture				
	Aug. 7th.	Aug. 14th.	Aug. 21st.	Aug. 28th	Average
170°F.	14·5	13·3	15·9	15·7	14·9
220°F.	14·5	13·4	14·0	14·9	14·2

The low fired tea is valued equal to the high fired tea on the first occasion, slightly poorer on the second, and much better on the two last occasions, and it is these last two sets of valuations which account for the big difference in the averages. Much of the value of the statistical tests of significance applied to

experimental results lies in the fact that these tests preclude as far as possible the risk of false conclusions being drawn, by insisting that a difference between averages of a number of replicated observations, shall not be significant unless there is a certain measure of agreement among the replicates.

When the taster reported on the teas sent to him immediately after manufacture he remarked, "At the moment the best fired teas have not matured while the poorly fired teas have not had a chance to go flat". On his own valuations and reports, however, of the same teas sent to him after 4 months, there are no indications of maturing or of "going flat" in any of the samples. One must therefore conclude that, if teas are efficiently stored and packed, no serious deterioration occurs in 4 months, even in the case of teas fired at low temperatures, provided they are brought out of the dryer fully fired and are packed before they have had time to absorb excessive amounts of moisture.

(2). *Teas fired at different temperatures for times only sufficient to reduce their moisture contents to 3%.*

Firing temperature °F	Time of firing : Minutes	Average valuations of Calcutta tasters in annas and pies	
		After manufacture	After keeping 4 months
175	47½	10- 2·9	9-10·3
190	40	10- 2·8	9- 8·2
205	32½	9-11·5	9- 7·7
220	25	9- 7·3	9- 6·6
	Average	10- 0·12	9- 8·21
Significant difference (P=·05).		0- 1·54	0- 1·24 pies.

The low fired tea (175°F) is significantly the best, after keeping, though it was not better than the 190°F fired tea when valued immediately after manufacture. As in the previous experiment the higher fired teas have improved relatively to the lower fired teas on keeping, but the 220°F fired tea is still significantly poorer than the tea fired at 190°F or 175°F.

In neither experiment have tasters detected any sign of "going off" or softness on the low fired teas. Generally speaking, there was a touch of "oldness" on all the kept teas and a loss of briskness as compared with the fresh samples. The following remarks by one taster however are of interest. "These sets have kept rather better than the average Assam during the rains period". The method of storage, of course, prevented absorption of water.

The London taster "L," also valued these teas made in September (fired at different temperatures, in each case for just sufficient time to ensure full firing); valuations being obtained as before on the teas sent immediately after firing and after keeping for 4 months.

The valuations are as follows :—

Firing temperature	Time in the dryer	Average valuations in pence	
		After manufacture	After keeping 4 months
175°F.	47½ mins.	15·79	16·69
190°F.	40 „	15·57	16·31
205°F.	32½ „	15·17	16·17
220°F.	25 „	15·07	15·56

The differences between valuations on the teas before keeping are not quite on the required level of significance, but it is easy to see that, as valuations descend with increasing temperature of firing, the probablity, at least, is that high firing gives poorer results than low firing.

The valuations on the teas after keeping show extraordinarily concordant results. On 3 of the four sets of teas, valuations were in inverse order to firing temperature, while on the other set, the only variation in this order was that the 205°F fired tea got ¼*d*. more than the 190°F fired tea. With results so concordant as this, significance in the average valuations is

assured. The required significant difference is 0.4*d*. The effect, then, of firing temperature on valuation of teas after keeping is that teas fired at 220°F are significantly poorer than teas fired at 205°F, 190°F, or 175°F. Teas fired at 175°F are moreover significantly better than those fired at 205°F but not significantly better than those fired at 190°F.

There is every reason to conclude from these results, that keeping has not resulted in a deterioration of low fired tea or in relative improvement of high fired tea.

VIII. VARIATION OF DRY WEIGHT OF FRESH LEAF, WITH MANURING AND PLUCKING.

Moisture determinations have been made at intervals during the season, on leaf samples from various plots under different plucking and manuring treatment at Borbhetta. Samples were collected from plucking baskets immediately the plucking of the particular plot was finished, and moistures were determined immediately, at Borbhetta. In the case of the plucking plots, the effects of four different plucking treatments were investigated, and samples were taken from 8 replicated plots of each plucking treatment. In the case of one set of manuring treatments there were 5 replicates, and in the other, 6.

(*a*). *Effect of plucking.*

Table of dry weight per cent of fresh leaf.

Date of plucking	Very coarse plucking	Superfine plucking	Fine plucking	
			Heavily broken back	Not broken back
4/7	22·50	23·68	23·74	23·78
18/7	22·45	23·72	23·19	23·29
1/8	23·24	24·20	24·03	24·03
15/8	23·14	24·10	23·56	23·56
Average	22·83	23·92	23·63	23·67

The significant difference for the final average is 0.32%.

For equal weight of fresh leaf, coarse plucking has given significantly the least dry weight. The superfine plucking has given a bigger dry weight than the fine pluckings, though the difference is not quite on the 5% level of significance.

Extremes of severity in closeness of plucking do not differ significantly over the period during which the determinations were made. Actually, very coarse plucking gives just over 4% less dry weight of crop than superfine plucking does, for the same weight of plucked fresh leaf.

(*b*). *Effect of quantity of chemical mixture, supplying nitrogen potash and phosphoric acid in the ratio 2/1/1.*

Table of Dry weight per cent of fresh leaf.

Date of plucking	*Nitrogen lbs. per acre			
	Nil	40 lbs.	80 lbs.	120 lbs.
24/6	24·23	23·61	23·48	23·79
1/7	23·48	24·12	23·77	22·18
8/7	23·20	23·62	22·87	22·95
15/7	24·23	24·25	24·20	24·03
22/7	24·02	23·43	23·27	23·02
29/7	24·32	24·30	22·82	23·33
6/8	23·70	23·22	23·02	22·45
12/8	24·22	23·92	23·45	23·40
Average	23·91	23·83	23·38	23·14

* The nitrogen dose was accompanied in each case with half the quantity of potash and phosphoric acid.

Figures in the above table are averages of 6 replicate plots for each treatment.

From plots manured with chemical manure supplying 120 lbs. nitrogen and 60 lbs. each of potash and phosphoric acid, the dry weight of leaf is 3% less than that from an equal weight of fresh leaf off unmanured plots. The significant difference is 0.41%. Thus the leaf from unmanured and 40 lbs. nitrogen plots gives significantly more dry weight than that from the 80 or 120 lbs. nitrogen plots.

The increase in moisture content of leaf from the heavily manured plots may be due partly to the potash, though probably it is due mainly to the heavy nitrogen application.

(c). Effect of phosphoric acid and potash.

The plot series on which determinations of moisture were made were as follows :—

Series	Manure lbs. per acre			Marked in table of dry weight
	Nitrogen	Phosphoric acid	Potash	
1	nil	nil	nil	nil
2	40	0	0	N
4	40	0	60	NK
13	40	60	0	NP
16	40	60	60	NPK

The figures in the table of dry weight given below, are averages for 5 replicate plots.

Table of dry weights per cent of fresh leaf.

Date of plucking	Manuring treatment				
	Nil	N	NK	NP	NPK
25/6	21·32	21·19	21·37	21·41	20·87
9/7	24·16	24·46	23·76	23·74	23·82
23/7	23·54	23·92	23·44	23·56	23·50
6/8	24·00	24·24	23·36	23·86	23·70
Average	23·25	23·53	22·98	23·39	22·97

Here the differences are not significant. It was pointed out by the Botanist in 1933 that one might expect to find a higher moisture content (lower dry weight) in leaf from plots heavily manured with potash. The figures above, although the differences are not significant, are suggestive that a larger number of observations might confirm the expectation.

VIII. COMPARISON OF TANNIN CONTENT OF TEA LIQUOR AND THAT OF BETEL NUT, PAN LEAF AND CATECHU.

It has been stated that one factor which restricts the sale of tea in India is the idea that by reason of its tannin content, it may prove harmful to the digestion.

It is known however that the "pan-supari" which is almost universally consumed by the Indian population without apparent harm also contains tannin, and a detailed analysis of the tannin content of the various constituents has been carried out. The results are given below :—

The materials were collected by purchase in the ordinary market.

	Moisture %	Tannin on dry matter %	Tannin % on material as purchased
Betel nut, dried ...	12·97	3·97	3·45
„ „ green ...	54·96	2·84	1·28
Pan leaf, deshi ...	84·53	0·87	0·13
„ „ sachi ...	86·28	1·36	0·19
Catechu Khoir "Papri"...	8·00	8·59	7·90
„ „ "Mogi"...	22·12	45·93	35·75

The deshi pan leaf is the variety commonly used in Assam : it sells at 20 leaves per pice. The Sachi pan is of superior quality, more aromatic and more astringent : it is imported from Bengal and sells at 1 leaf per pice in Assam.

"Papri" is the dried aqueous extract of leaves and young shoots of the plant *Ancaria gambier,* sold in reddish brown cubes of side about 1 inch. "Mogi" is the dried aqueous extract of the wood of the tree *Acacia catechu* sold in black shiny irregular masses. Both contain the tannin usually known as catechu-tannic acid, which is converted to catechin by the saliva. Both are used in medicine in the treatment of diarrhoea, the prescribed dose of either "Papri" or "Mogi" being 5 to 15 grains.

"Mogi" is very astringent and also bitter, and is less used in Assam than the "Papri" for chewing. "Khilipans" are sold

consisting of betel nut, "khoir" and lime, with a little spice (perhaps one clove in cheap "khilipans") all wrapped in a pan leaf ready for chewing.

A number of such "khilipans" were analysed. All these were made with the mild "Papri". "Mogi" is not commonly used in Assam. The average "khilipan" weighs 5½ grams, and contains a total of .056 grams (or 0.84 grains) of tannin. The average moderate chewer takes about 20 "Khilipans" a day, thus taking about 17 grains tannin daily, the whole of which is normally swallowed. Addicts chew all day, consuming 70 to 100 "khilipans". A cup of tea normally contains 3 grains tannin. A normal tea drinker taking 5 to 6 cups daily, therefore would consume about as much tannin as a very moderate chewer of pan.

IX. HUMUS COMPOSTS.

During 1935 a large number of samples of prepared composts intended as manure for tea, have been examined and analysed. In addition, several complete analyses of the materials, *i.e.*, green vegetable matter, cow dung, urine and urine earth, prior to composting, and of the finished compost prepared therefrom, have been made. With the weights of materials before composting, and the weight of compost obtained, "balance sheets" have been drawn up showing the loss or gain from the composting process.

Analyses show that as far as nitrogen, ash and organic matter content are concerned, wide variations exist between the different samples submitted. The majority of samples show an average nitrogen content of about 0.4% and organic matter of about 10% on the sample as received. These samples have generally been obtained by preparing heaps of waste vegetable matter (*e.g.*, green jungle, boga medeloa, eupatorium, crotalaria striata cuttings, etc.) and cattle manure in alternate layers in the proportion of roughly 4 or more parts by weight of vegetable matter to one of cattle manure. The samples have been sent usually after the heap has been lying for 3 months or more. The cattle manure, supplemented in a few cases by urine earth, is

added with the purpose of supplying (*a*) organisms which will break down the vegetable matter to humus, and (*b*) the readily available nitrogen and other minerals required by these organisms during their work of decomposition. In certain cases, samples of humus received have been prepared without the use of waste animal products (cattle manure, etc.), chemical fertilisers such as nicifos having been employed to provide the readily available nitrogen. The necessary organisms in these cases are provided by the soil attached to the root portions of the vegetable matter, or in soil added to the compost heap during its preparation.

In view of the fact that on an average, the type of waste vegetable matter and cattle manure normally used, contains about, .5 to 1% nitrogen and about 30% organic matter, the analyses of finished compost in general disclose an unsatisfactory state of afairs. Organic matter and nitrogen are being lost to a very considerable extent during the composting process.

The following figures, obtained from an experimental compost stack prepared at the beginning of October illustrate the extent of the losses resulting from the compost process.

Weight in lbs.

	Original materials	Finished compost	Loss or gain
Total weight ...	1260	1380	+120
Organic matter ...	747	124	−613
Ash (including soil) ...	25	499	+474
Water	488	757	+269
Nitrogen	11½	5	− 6½

An examination of several compost stacks during the dry season of the year provides one reason for the results obtained above, since of over 20 heaps examined all were infested with white ants which were busily engaged in destroying organic matter and substituting soil in its stead.

There seems to be considerable difficulty, particularly during the cold weather months, in getting the stacks to heat up as they should. It is sometimes found that the stacks heat up at first but when turned over, to ensure aerobic conditions, subsequent development of heat does not occur.

XI. SOIL ACIDITY.

That tea requires an acid soil has been known for a long time. The optimum value is not fixed however and will naturally vary according to soil type. Tea is growing well on certain very sandy soils with pH values in the region of 6.0. On very stiff flats and bheels of pH 5.6 to 5.8, tea may possibly be suffering from under-acidity of the soil, and may be improved by treatment with sulphur or other acidity-increasing manures. The main work on soil acidity has consisted in determining the acidity of poor areas of tea and of areas intended for replanting and for nurseries. In cases where the acidity is considered low for the type of soil, determinations of the amount of sulphur required to produce a satisfactory soil acidity for tea, have been made.

At Tocklai a series of plots of tea was treated with sulphur in varying amounts in 1933, with the object of studying the growth of tea on soils of different degrees of comparatively high soil acidity.

Sufficient sulphur has been applied to give four ranges of pH value, *viz.*, 5.4, 4.8, 4.0 and 3.6. Up till the season 1935 no significant difference in crop of tea, or in appearance of bushes was observed. The soil on the highly sulphured plots has however remained free from jungle growth.

In 1935 the bushes on heavily sulphured plots (soil pH value 3.6) began to go back in appearance, and the crop showed a decrease relative to the 1934 yields. There are as yet, however, no significant differences between the yields from the four treatments taking co-variance on the corresponding yields before treatment.

The variations in acidity of soil samples from the four series of plots, over the three years 1933, 1934 and 1935 are shown in the accompanying curves. The pH values of all plots are highest in the middle of the cold weather, when soil temperature and soil moisture is lowest. The pH drops to its lowest value in the middle of the rains when the soil is warmest and wettest. It is interesting to observe that, in the 1934-35 cold weather when soil moisture remained fairly high owing to a high rainfall towards the latter part of 1934 rains, the soil pH value does not show the characteristic rise to the same extent as it did in previous years.

XI. ANALYSIS OF TEA PRUNINGS.

Samples of prunings from top pruned bushes on 16 plots at Borbhetta were analysed for nitrogen, potash, phosphoric acid, moisture and ash. The area was planted in 1928 and the average yield per acre of tea in 1935 was about 11 mds. tea per acre. The average dry weight of prunings per acre was about 1½ tons per acre. There are four series of plots each series replicated four times. The treatments which commenced in 1934-35 cold weather, applied are as follows.

Series 1. Prunings hoed in with the deep hoe, and a mixture to give 40 lbs. nitrogen and 20 lbs. each of potash and phosphoric acid light hoed in, in March.

,, 2. Prunings hoed in with deep hoe. Unmanured.

,, 3. Prunings removed. Unmanured.

,, 4. Prunings removed. Manured as for series 1.

The following are results of analyses of prunings collected in December 1935.

(*a*). *Nitrogen Content.*

	Percentage on dry weight of leaf			Percentage on dry weight of stems		
	Manured	Not manured	Average	Manured	Not manured	Average
Prunings buried	2·21	2·04	2·12	1·22	1·14	1·18
Prunings removed	2·09	2·07	2·08	1·17	1·04	1·10
Average	2·15	2·06	2·10	1·20	1·09	1·14

The differences in nitrogen content are not significant, but there is an indication that manuring increases nitrogen content of leaf and stem of prunings.

(*b*). *Potash.*

	Percentage on dry weight of leaf			Percentage on dry weight of stem		
	Manured	Not manured	Average	Manured	Not manured	Average
Prunings buried	·699	·723	·711	·541	·537	·539
Prunings removed	·664	·674	·669	·506	·514	.510
Average	·681	·699	·690	·523	·525	·524

The differences in both cases just fall short of significance—four replicates only of each of the four treatments, being insufficient to eliminate the inaccuracies of sampling, analysis, etc.

It is probable however, that, while manuring has had no appreciable effect on the potash content of prunings (particularly in the case of the stem), the burial of prunings in the previous cold weather has resulted in an increase in the potash content of the following season's prunings.

(*c*). *Phosphoric acid.*

	Percentage on dry weight of leaf			Percentage on dry weight of stem		
	Manured	Not manured	Average	Manured	Not manured	Average
Prunings buried	·294	·306	·300	·173	·179	·176
Prunings removed	·276	·319	·297	·174	·158	·166
Average	·285	·312	·298	·173	·168	·171

Significant difference of average = .025%.

The only significant effect on the phosphoric acid content of prunings is that manuring has significantly reduced the phosphoric acid in the leafy portion only.

(*d*). *Moisture.*

	Percentage on dry weight of leaf.			Percentage on dry weight of stem.		
	Manured	Not Manured	Average	Manured	Not manured	Average.
Prunings buried ...	62·3	63·0	62·6	63·5	63·8	63·6
Prunings removed ...	62·1	62·1	62·1	62·5	60·4	61·4
Average ...	62·2	62·5	62 3	63·0	62·1	62·5

(*e*). *Ash.*

	Percentage on dry weight of leaf.			Percentage on dry weight of stem.		
	Manured	Not manured	Average	Manured	Not manured	Average
Prunings buried ...	7·52	7·39	7·45	4·50	4·60	4·55
Prunings removed ...	7·40	7·88	7·64	4·35	4·32	4·33
Average ...	7·46	7·63	7·54	4·42	4·46	4·44

The results show no significant differences.

Under normal conditions, when prunings are buried annually and a moderate dose of manure mixture is applied, on areas giving about 11 mds. per acre of tea, a crop of about 3,500 lbs. per acre dry weight of prunings is obtained, consisting of roughly equal parts of stem and leaf. The prunings therefore supply about 3,000 lbs. of organic matter, 60 lbs. nitrogen, 20 lbs. potash and 8 lbs. phosphoric acid per acre per annum.

XII. WEATHER REPORT FOR 1935.

General Climatic Conditions at Tocklai.

There was practically no rain in January, but following on good rainfall towards the latter part of 1934 the soil remained only slightly below the optimum of 17% for the greater part of the month. Temperatures were slightly lower than normal. In February, rainfall was rather above average and weather was cool and dull. In March although 3½ ins. of rain fell, rather above average for the month, most of it fell during the last few days of the month. Nearly 2 inches fell on the 27th night accompanied by high wind and hail (smooth stones about ⅓"

diameter) which fortunately did little damage to tea at Tocklai or Borbhetta. Several gardens nearer the hills however suffered very severely on cut-back areas. Soil moisture dropped from 16% to 12% up to the time when the rain fell, after which it rose to 17%. April rainfall was half the normal 8", but was well distributed and soil moisture remained at 16% throughout the month. One or two severe wind storms, accompanied on one occasion by hail, were experienced but no damage was done. An earthquake shock of slight intensity occurred at 11.5 p.m. local time on the 23rd. May rainfall was normal, with temperatures slightly higher than normal; soil moisture was over 18% throughout the month and remained so until the middle of October.

High temperature and humidity, and copious rainfall were characteristic of the weather in June and July. August was exceptionally cool, rainfall short of normal. With little sun or drying wind the soil moisture remained over 19½% and rose to 20% at the end of September, following another cool spell.

October was easily the dryest on record for 18 years, with only 0.15 ins. of rain which fell in 3 light showers at night, leaving no trace of moisture on the ground by 10 o'clock next day. The previous lowest October rainfall was 2.03 ins. in 1918, while the normal precipitation is 5.8 ins. In spite of the low rainfall October was a fairly good cropping month as there was plenty of moisture in the soil until the last week when it had fallen to 14½%. During November dry conditions continued, and soil moisture fell to 12%. Maximum temperature and sunshine were considerably above normal, and the water level was falling rapidly. No rain fell in December and soil moisture reached a record low figure of 8% at Tocklai. Supply of water was beginning to be a problem at the end of the month.

Tables below give comparative monthly rainfall, sunshine and temperature observations for Tocklai, Doom Dooma and Western Dooars. The two latter sets of figures are available

through the courtesy of the Scientific Officer, Associated Companies, Doom Dooma; and the Manager, Sylee Tea Estate.

Rainfall.

Month	Assam				Dooars	
	Tocklai		Doom Dooma		Sylee	
	Inches	Wet days	Inches	Wet days	Inches	Wet days
January ...	0·11	3	·38	4	0·45	3
February ...	2·08	13	4·44	11	2·34	10
March ...	3·48	7	5·32	11	1·51	4
April ...	4·42	12	11·12	16	0·80	6
May ...	10·79	25	14·55	23	10·35	14
June ...	18·51	26	25·79	25	32·83	28
July ...	17·13	24	20·43	22	35·57	29
August ...	12·21	25	14·82	22	42·77	29
September...	12·63	23	15·09	20	25·26	21
October ...	0·15	3	0·22	3	1·06	6
November ...	0·37	3	0·87	5	0·03	1
December ...	0·03	1	0·29	2	0·35	1
Total ...	81·91	165	113·32	164	153·32	152

It is interesting to observe that, although a much heavier rainfall occurs in Doom Dooma and in the Dooars than at Tocklai, the number of days on which it fell is only about the same in Doom Dooma, and considerably less in the Dooars. Individual precipitations in these districts during the rains months are considerably heavier than at Tocklai, and drainage arrangements to remove excess water after heavy storms are probably of considerably more importance than they are at Tocklai. At Sylee, June, July and August are the only months during which there are more wet days than at Tocklai. During the remaining 9 months the number of wet days is considerably less. From the end of September to the end of May, rainfall is normally lower and less well distributed in the Dooars than in Assam.

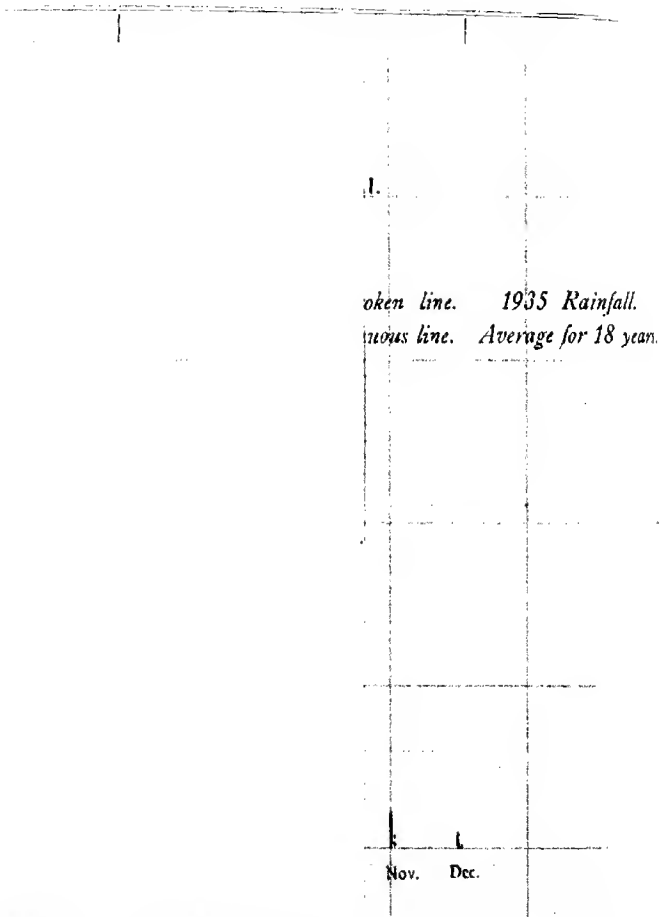
The average monthly rainfall at Tocklai over the past 18 years (1918 to 1935 inclusive) is as follows :—

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Inches	0·92	1·44	3·05	8·05	9·63	14·82	15·06	14·07	11·12	4·32	1·12	0·39	84·

than those of Upper Assam throughout the year, and are also higher than the Western Dooars, during July, August and September. Minimum (night) temperatures are much the same for all three districts, Western Dooars being on the whole the highest, and Doom Dooma the lowest, except during July, August and September when these latter are highest of all.

through the courtesy of the Scientific Officer, Associated Companies, Doom Dooma; and the Manager, Sylee Tea Estate.

Rainfall.



~~Greatly more important than they are at Tocklai.~~ At Sylee, June, July and August are the only months during which there are more wet days than at Tocklai. During the remaining 9 months the number of wet days is considerably less. From the end of September to the end of May, rainfall is normally lower and less well distributed in the Dooars than in Assam.

The average monthly rainfall at Tocklai over the past 18 years (1918 to 1935 inclusive) is as follows :—

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Inches	0·92	1·44	3·05	8·05	9·63	14·82	15·06	14·07	11·12	4·32	1·12	0·39	84·

Maximum and minimum Shade Temperatures.

The following are monthly maximum and minimum shade temperatures during 1935 for Tocklai, Doom Dooma and Western Dooars.

Month	Tocklai		Doom Dooma		Sylee	
	max. °F	min. °F	max. °F	min. °F	max. °F	min. °F
January ...	71·5	46·9	70·7	46·0	72·4	48·0
February ...	73·1	53·5	71·8	51·1	76·0	54·1
March ...	83·2	59·6	81·1	57·9	87·6	58·7
April ...	83·6	63·7	81·7	62·3	90·2	62·0
May ...	85·4	70·8	83·2	70·6	89·0	71·6
June ...	87·1	73·0	84·0	73·8	87·3	74·0
July ...	91·1	74·7	90·0	77 2	89·4	75·7
August ...	88·6	73·9	86·9	75·7	86·6	74·4
September...	88·7	73·1	85·8	74·7	86·5	73·4
October ...	87·0	67·8	86·5	67·1	88·3	64·9
November...	81·4	58·3	80·0	59·4	83·6	57·8
December ...	74·3	47·2	72·7	47·5	77·2	48·8

The Western Dooars district experiences higher day temperatures than the two other localities, from the end of September to the end of June. Tocklai day temperatures are higher than those of Upper Assam throughout the year, and are also higher than the Western Dooars, during July, August and September. Minimum (night) temperatures are much the same for all three districts, Western Dooars being on the whole the highest, and Doom Dooma the lowest, except during July, August and September when these latter are highest of all.

TABLE II.

Individual average valuations of 6 Calcutta tasters.

Valuations in annas and pies.

Manuring treatment lbs. per acre			Method of application	Tasters						
				A	B	C	D	E	F	Average
N.	P.	K.								
0	0	0	...	11- 0·7	10-0·0	10-6·6	10-10·1	10-11·4	12- 1·9	10-11·1
40	20	20	1 dose in March	11- 0·7	10-2·7	10-4·1	10-11·2	10- 8·9	12- 3·0	10-10·6
80	40	40	1 dose in March	10-10·4	10-3·9	10-3·7	10- 6·7	10- 7·2	11- 9·0	10- 8·9
120	60	60	1 dose in March	10-10·4	10-2·1	10-2·2	9-10·5	10- 7·1	11-10·5	10- 7·1
40	20	20	2 doses March and end of June	11- 2·9	10-0·5	10-0·1	10- 1·5	10-11·0	11- 8·2	10- 8·2
80	40	40	2 doses March and end of June	10- 8·4	9-9·2	9-9·6	10- 0·1	10- 8·2	11- 9·4	10- 5·5
120	60	60	2 doses March and end of June	11- 0·0	10-1·5	10-0·0	10- 2·0	10- 8·0	11-10·5	10- 7·7
80	40	40	2 doses March and mid-May	10- 8·9	9-7·7	10-5·0	10- 1·4	10- 9·7	12- 1·1	10- 7·6
Average				10-10·9	10-0·5	10-2·4	10- 3·9	10- 9·0	11-11·2	10- 8·3
Significant difference in pies				...	...	...	0-7·34	0-2·87	...	0- 3·0

TABLE III.

Average weekly valuations of 4 London Tasters.

Valuation in pence.

Manuring treatment lbs. per acre			Method of application	June			July					
				4th	18th	25th	2nd	9th	16th	23rd	30th	Average.
N.	P.	K.										
0	0	0	...	14·4	14·0	13·7	14·0	14·6	14·4	14·7	15·5	14·43
40	20	20	1 dose in March	16·1	13·6	13·6	13·5	13·8	13·9	15·2	14·4	14·28
80	40	40	1 dose in March	14·5	13·3	13·5	13·6	13·8	14·2	14·5	15·1	14·06
120	60	60	1 dose in March	15·0	13·4	13·6	13·6	14·3	13·5	13·5	14·1	13·89
40	20	20	2 doses March and end of June	14·8	13·7	13·8	13·2	14·2	15·6	14·6	15·0	14·36
80	40	40	2 doses March and end of June	14·7	13·2	13·6	13·3	13·6	15·1	14·4	14·3	14·08
120	60	60	2 doses March and end of June	14·9	13·4	13·5	13·5	14·4	13 4	14·3	14·4	13·98
80	40	40	2 doses March and mid-May	14·2	13·1	13·4	13·3	14·5	14·2	15·0	14·6	14·05
Average			... ...	14·8	13·5	13·6	13·5	14·2	14·3	14·5	14·7	14·14

Significant difference = 0·33d

TABLE IV.

Individual valuations of 4 London Tasters.

In pence.

Manuring lbs. per acre			Method of application.	Tasters.				Average
N	P	K		H	J	K	L	
0	0	0	...	14·8	12·8	14·0	16·1	14·43
40	20	20	one dose in March	14·3	12·8	14·2	15·8	14·28
80	40	40		14·4	13·0	13·8	15·1	14·06
120	60	60		14·5	12·6	13·5	15·0	13·89
40	20	20	two doses March and end of June	14·2	13·1	13·9	16·1	14·36
80	40	40		14·1	13·1	13·9	15·2	14·08
120	60	60		14·0	13·1	13·8	15·0	13·98
80	40	40	two doses, March and mid-May	14·1	12·6	14·2	15·4	14·05
			Average ...	14·30	12·90	13·91	15·46	14·14

TABLE V.

Average valuations of 6 Calcutta Tasters.

In annas and pies.

Term applied to the style of plucking	Date of Manufacture.								Average
	May	June				July			
	31st	7th	14th	21st	28th	5th	12th	19th	
Superfine ...	11- 0·00	11-5·50	12-2·00	11-1·50	11-0·67	10- 6·67	10- 5·00	10- 8·11	11- 0·69
Fine: heavily broken back	11-11·00	11-5·50	11-5·50	10-11·33	11-1·00	10-10·50	9- 7·17	10- 5·50	10-11·69
Fine: broken to janam	11- 5·00	11-3·00	11-3·83	10- 9·00	11-1·00	10- 6·50	10- 0·50	10- 3·17	10-10·00
Fine: not broken back	10-10·50	11-5·00	11-5·33	10-10·83	10-8·83	10- 2·83	9-10·50	10- 8·83	10- 9·34
Fine: no banjhis plucked	11- 0·67	11-7·50	11-4·67	10- 3·50	11-0·33	10- 9·50	9- 8·50	10-10·83	10-10·19
Medium	11- 3·00	11-7·33	10-7·50	10- 9·00	10-4·50	10- 2·50	10- 3·60	10- 2·17	10- 7·94
Coarse	10- 2·83	11-5·00	10-3·00	9- 8·00	9-6·00	9- 1·00	8- 9·00	9- 6·60	9-10·20
Very coarse	8-10·50	9-6·50	9-4·50	8- 9·00	8-6·00	8- 4·00	8- 2·50	8- 6·50	8- 9·05
Average	10- 9·40	11-2·66	11-0·67	10-4·77	10-4·92	10- 9·04	9- 7·33	10- 1·96	10- 5·648

TABLE VI.

Average valuations.

In annas and pies.

Term applied to the style of plucking	Tasters.						Average
	A	B	C	D	E	F	
Superfine ...	10-11·2	11- 1·2	11- 1·5	10- 3·4	10- 7·0	12- 3·7	11- 0·69
Fine: heavily broken back ..	10-11·6	11- 0·4	11- 1·7	10- 2·6	10- 9·0	11- 9·4	10-11·69
Fine: broken to Janam ...	10- 6·9	11- 2·0	10- 9·7	9-11·2	10- 8·7	11- 9·4	10-10·00
Fine: not broken back ...	10-1·04	11- 0·4	10- 5·6	9- 8·2	10-10·4	11- 9·0	10- 9·34
Fine: no banjhis plucked ...	10- 9·7	10- 9·0	10- 3·7	9- 5·6	10- 9·7	11-11·2	10-10·19
Medium ...	10- 6·0	10- 8·6	10- 8·2	9- 9·7	10- 5·2	11- 9·7	10- 7·94
Coarse ...	9- 5·6	9-10·9	9- 9·4	8- 7·5	10- 1·7	11- 2·6	9-10·29
Very coarse ...	8- 6·0	8- 9·0	9-10·5	7-10·5	9- 6·7	8-11·6	8- 9·05
Average ...	10- 3·9	10- 6·7	10- 6·2	9- 5·9	10- 5·8	11- 5·3	10-5·648
Significant difference ...	0- 5·1	0-10·8	3- 4·6	0- 9·1	0- 5·3	0- 8 0	

TABLE VII.

Average of 3 London Tasters.

Valuations in pence.

Term applied to the style of plucking	Date of manufacture								Average
	May	June				July			
	31st	7th	14th	21st	28th	5th	12th	19th	
Superfine ...	13·75	14·67	13·58	14·50	14·42	14·00	13·08	14·17	14·02
Fine: heavily broken back ...	13·42	14·25	13·29	14·33	14·00	13·58	13·12	13·46	13·68
Fine: broken to janam ...	14·00	14·50	13·12	14·42	13·00	13·08	12·58	13·00	13·46
Fine: not broken back ...	13·29	14·25	12·92	14·17	13·17	13·08	13·04	13·21	13·39
Fine: no banjhis plucked ...	12·83	13·42	13·25	13 92	13·17	13·58	12·92	13·75	13·35
Medium ...	13 83	13·58	13·25	13·58	13·42	13·42	12·71	13·17	13·37
Coarse ...	13·25	13·83	12·58	13·50	13·42	12·50	12·50	13·08	13·08
Very coarse ...	11·75	13·00	12·17	12·83	12·17	11·83	11·50	12·25	12·19
Average ...	13·25	13·93	13·02	13·90	13·33	13·12	12·67	13·25	13·32

Table VIII.

Individual valuations of 3 London Tasters.

In pence.

Term applied to the style plucking.	H	J	K	Average.
Superfine	14·50	13·94	13·63	14·02
Fine : heavily broken back ...	13·81	13·27	13·84	13·68
Fine : broken to janam ...	14·12	13·05	13·22	13·46
Fine : not broken back ...	13·97	12·78	13·42	13·39
Fine : no banjhis plucked ...	13·90	12·72	13·37	13·35
Medium	13·81	12·89	13·28	13·37
Coarse	13·41	12·94	12·97	13·08
Very coarse	12·20	12·13	12·25	12·19
Average ...	10·71	12·96	13·25	13·32
Significant difference ...	0·30*d.*	0·45*d.*	0·34*d.*	0·23*d.*

Table IX.

Average weekly valuations of 5 Calcutta Tasters.

In annas and pies.

Style of plucking	Date of manufacture.						Average.
	October		November				
	11th	18th	9th	16th	23rd	30th	
4" and to janam	10- 4·4	10-11·6	10- 3·0	10-10·2	10- 9·0	10-10.2	10- 8·07
8" „ „ „ ...	10- 7·4	10- 9·8	10-10·8	11- 2·0	10-11·8	11- 2·8	10-11·43
4" and one leaf left	10- 5·0	10- 9·8	10- 6·0	11- 0·6	10- 6·4	11- 1·4	10- 8·53
8" „ „ „ „	10-10·2	10-10·6	10-11·0	11- 2·8	10-11 8	11- 4·6	11- 0·50
High skiff ...	10-10·2	11- 2·8	10- 6·0	10- 9·6	10- 9·8	11- 2·4	10 10·80
Low skiff ...	10- 2·0	10- 7·8	10- 6·2	10-10·8	11- 1·4	10- 8·4	10- 8·10
Average ...	10·65	10-10·4	10- 7·2	11- 0·2	10-10·4	11- 0·6	10- 9·90

Significant difference, ($P = ·05$) = 2·41 pies.

Table X.

Individual valuations of 5 Calcutta Tasters.

In annas and pies.

Style of plucking.	Tasters.					Average.
	B.	C.	D.	E.	F.	
4″ and to janam ...	10- 7·5	11-4·5	8-11·0	11-0·8	11-4·5	10- 8·07
8″ ,, ,, ,, ...	10- 9·3	12-5·0	8-11·2	11-2·2	11-5·5	10-11·43
4″ and one leaf left	10- 8·3	11-7·0	9- 0·3	11-2·0	11-1·0	10- 8·53
8″ ,, ,, ,, ,,	10- 8·2	12-6·5	9- 1·3	11-3·0	11-7·5	11- 0·50
High skiff ...	10-10·5	11-9·0	8-11·2	11-2 8	11-8·5	10-10·80
Low skiff ...	10- 6·2	11-6·0	8-11·3	11-3·0	11-2·0	10- 8·10
Average ...	10- 8·3	11-10·3	8-11·4	11-2·3	11-4·8	10- 9·90
Significant difference (P = ·05) ...	...	1-10·0 pies.	...	...	4·61 pies.	2·41 pies.

Table XI.

Average weekly valuations of 5 London Tasters.

In pence.

Style of plucking.	Date of manufacture.						Average.
	October		November.				
	12th	19th	9th	16th	23rd	30th	
4″ and to janam ...	13·9	14·5	14·1	14·6	14·3	14·3	11.28
8″ ,, ,, ,, ...	14·4	14·6	15·0	14·6	14·2	14·8	14·59
4″ and one leaf left	14·3	13·8	14·6	14·8	14·6	14·7	14·47
8″ ,, ,, ,, ,,	14·6	13·7	15·0	15·3	14·5	15·0	14·66
High skiff ...	14·0	14·6	14·6	14·9	14·5	14·7	14·53
Low skiff ...	13·8	13·5	14·0	14·5	14·4	14·5	14·14
Average ...	14·2	14·1	14·5	14·8	14·4	14·7	14·45

Significant difference of averages = 0·33*d*.

Table XII.

Average individual valuations of London Tasters.

In pence.

Style of plucking.	Tasters.					Average
	H.	J.	K.	L.	M.	
4″ and to Janam ...	14·8	12·6	14·1	16·8	13·1	14·28
8″ „ „ „	15·0	13·1	14·3	16·8	13·7	14·59
4″ and one leaf left ...	14·6	12·8	14·3	17·2	13·4	14·47
8″ „ „ „ „ ...	14·9	13·3	14·7	17·1	13·4	14·69
High skiff ...	14·8	12·9	14·7	17·0	13·3	14·53
Low skiff ...	14·2	12·8	14·0	16·8	12·9	14·14
Average ...	14·7	12·9	14·3	16·9	13·3	14·45
Significant difference (P = 05)	...	...	0·46d	...	...	0·33d.

Table XIII.

Average weekly valuations of 6 Calcutta Tasters.

In annas and pies.

Jat	Dates of manufacture								Average
	26th July	2nd Aug.	9th Aug.	16th Aug.	23rd Aug	30th Aug	6th Sept.	13th Sept.	
Betjan	10- 6·5	10- 5·2	10- 3·0	10- 7·9	10- 4·7	10- 5·4	10- 3·9	9-11·3	10- 4·51
Singlo	9-10·6	9- 7·7	9-11·0	9- 9·7	9- 8·1	9- 5·6	9- 7·7	9- 7·8	9- 8·56
Kalline	10- 4·8	10- 2·7	10- 0·7	9-10·6	10- 0·0	10-1·1	9-11·1	9-10·9	10- 0·75
Panighat	10- 5·7	10- 1·5	9-11·4	9- 9·1	10- 3·6	10- 0·0	9-10·9	9- 8·0	10- 0·30
Pruning.									
One year wood	10- 4·1	10- 2·8	10- 1·9	10- 1·6	10- 1·9	10- 1·0	10- 0·0	9-10·2	10- 1·45
Two year wood	10- 3·8	9-11·8	9-11·2	9-11·1	10- 0·3	9-11·1	9-10·8	9- 8·8	9-11·61
Average	10- 3·9	10- 1·3	10- 0·5	10- 0·3	10- 1·1	10- 0·0	9-11·4	9- 9·5	10- 0·55

Significant difference (a) of Jat average = 1·55 pies.
P = ·05 (b) of pruning average = 1·09 pies.

TABLE XIV.

Individual valuations of 6 Calcutta Tasters.

In annas and pies.

Jat.	Tasters.						Average.
	A.	B.	C.	D.	E.	F.	
Betjan ...	10-7·3	9-11·6	9-3·4	10-10·9	10-1·6	11- 4·1	10-4·51
Singlo ...	10-1·5	9- 5·6	9-1·2	9- 5·8	9-5·2	10- 8·1	9-8·56
Kalline ...	10-1·3	9-10·1	9-5 6	10- 2·4	9-9·5	10-11·6	10-0·75
Panighat...	10-1·1	9- 9·1	9-4·2	10- 3 7	9-8·8	10-10 1	10-0·30
Significant difference.	2·54 pies	2·97 pies	...	3·78 pies	2·31 pies	4·85 pies	1·55 pies
Pruning							
On one year wood ...	10-3·1	9-10·1	9-4·5	10-3·5	9-10·2	11-1·3	10- 1·45
On two year wood ...	10-2·4	9- 8·5	9-2·7	10-2·0	9- 8·4	10-9·7	9-11·61
Average ...	10-2·8	9- 9·3	9-3·2	10-2·7	9- 9·3	10-11·5	10- 0·53
Significant difference	...	...	...	...	1·63 pies	3·48 pies	1·09 pies

INDIAN TEA ASSOCIATION.

SCIENTIFIC DEPARTMENT.

(RESUMÉ)

Report by the Chief Scientific Officer on the work of the Department during the year 1935.

GENERAL.

The health of the staff throughout the year has been normal.

Dr. W. Wight was on seven months home leave during the year.

During April and May, I visited the tea districts of the Netherland East Indies, Java, in the company of Mr. Forbes, the President and Dr. Norris the Director of the Tea Research Institute of Ceylon, but unfortunately I alone continued the tour in Sumatra. This visit afforded the first opportunity that has ever arisen for three Directors of the experimental tea stations to meet together and to discuss their various problems. It is to be hoped that this form of co-operation will be developed and that the various Officers of the scientific stations will have the opportunty of meeting their co-workers. I have to express my great appreciation of the hospitality and kindness that was extended to me whilst in the Netherland East Indies. An account of the visit has been prepared for publication.

Later in the year Mr. Cooper paid a visit to Ceylon in order to visit the Tea Research Station. This visit has been much appreciated by Mr. Cooper and an account of it is being published.

Towards the end of the year Dr. Eden, the Soil Chemist of the Tea Research Institute of Ceylon paid a visit to Tocklai.

Such visits afford the opportunity for officers to discuss their various problems together and provide the necessary and desirable co-operation that allows of the required co-ordination of investigation work.

During the year many experimental tea samples were made and we have to express our thanks to Messrs. Ewart Maccaughey & Co., Lloyd Matheson & Carritt, Shepard & Co., Stenning Inskipp & Co., Thomas Cumberlege & Moss, and George White & Co. of London, and to Messrs. Carritt Moran & Co., W. S. Cresswell & Co., Davenport & Co. Ld., A. W. Figgis & Co., J. Thomas & Co. and to the Jorehaut Tea Co. Ltd. (Mr. R. Gilchrist) of India, for the help and assistance they have given in reporting upon and valuing the experimental teas.

During the year no increase of staff has taken place and work particularly in the Chemical and Botanical laboratories is being seriously retarded.

The following visits were made during the year.

Touring 1935.

Months.	P. H. Carpenter.	H. R. Cooper.	A. C. Tunstall.	C. J. Harrison.	S. F. Benton.	W. Wight.	M. Singh.
January	Calcutta and Delhi.	...	...	...	...	...	...
February	Delhi.	...	...	...	...	...	...
March ...	Darjeeling	...	...	Cachar	...	...	...
April ...	Dutch East Indies.	...	Sylhet and Cachar.	...	...	Calcutta.	Dooars.
May ...		...		Golaghat	...		...
June ...		...	...	...	...		...
July ...	Simla and Calcutta.	Ceylon.	...	...	...	HOME LEAVE	...
August	Calcutta and Simla.	...	Jorhat Sibsagar.	...	...		...
Sept. ...		...	Sylhet Cachar.	...	Nowgong Doom Dooma		...
October	...	...	...	Dooars	Margherita.		...
Nov. ...	Dibrugarah	Dibrugarah Doom Dooma	Sibsagar.	...	...		...
Dec. ...	Calcutta.	...	Sibsagar.	...	...	Calcutta.	...

The necessary repairs to buildings have been carried out.

During the year 4,259 letters were received by the Department and 4,855 letters were despatched.

The total number of samples and specimens received during the year were :—

Chemical Branch ...	...	...	...	1687
Entomological Branch	...	...	...	72
Mycological Branch	...	...	...	1135
Bacteriological Branch	...	...	...	142
Botanical Branch ...	...	...	...	23

excluding 17 samples of tea seed.

Four Lecture Courses were held during the year—two in January and two during November-December.

There were 180 visitors to the Station during the year.

I was reappointed as a member of the Advisory Board of the Imperial Council of Agricultural Research. This Board re-elected me to represent them on the Governing Body of the Council.

CHEMICAL.

As in previous years investigations into the influence of factors such as manuring, plucking, jat of bush, on the value of the tea made have formed the most important part of the work of the Department during the past year.

In 1934 experiments were carried out on plucking during the rains period. This year the experiment was conducted during the second flush period in order to find out whether similar results would be obtained to those found for the rains period.

The conclusions arrived at by the tasters in Calcutta are that superfine plucking and heavy breaking back of normal fine plucking give teas which are preferred to medium or the coarse forms of plucking but there is no difference between the superfine and any of the normal fine forms of plucking. The two coarse pluckings give inferior teas, the very coarse plucking being inferior to the moderately coarse plucking. The conclusions arrived at by the London tasters differ somewhat and are as follows. The superfine pluckings have given teas which are regarded by the London tasters as of better quality than all the other forms of plucking. Among the four forms of fine plucking the harder the breaking back the better are teas though the difference is small. The teas from the most severe form of breaking back are better than those from tea not broken back at all.

In one of the fine pluckings banjhi leaf was entirely excluded. This has not resulted in better teas. The medium plucking consisting of 2 leaves and a bud and soft double banjhis has given teas which the London tasters consider poorer than those from the superfine and the fine plucking heavily broken back. The medium plucked teas, however, are not poorer than the other 3 styles of fine plucking.

Another experiment was carried out to ascertain whether leaving different lengths of initial growth resulted in the production of different teas during the autumnal period, and whether leaving a big leaf during the plucking round had any effect on the quality of the tea late in the season. The results show that the leaving of longer initial growth did slightly improve the teas. It was also noticed that tea skiffed after one month's growth so as to leave 3 leaves above the previous plucking level gave improved quality particularly for the 3 or 4 weeks immediately following the skiffing, as compared with tea skiffed back to the previous plucking level. This experiment was carried out in October.

Another experiment showed that tea made from the new growth developing from one-year old wood gave better quality tea than new growth developed from two-year old wood.

Last year experiments were carried out to ascertain the influence of jat upon quality. The trial has again been carried out this year during the rains period whereas in 1934 the experiment was carried out during October and November. The results this year are indefinite, the tasters expressing such opposing views that it is useless to attempt to obtain a general opinion. All that can be said is the types highly valued in Calcutta do not always receive the same preference in London. It is unfortunate that tasters when commenting on the teas did not comment on the liquors or infusions but expressed an opinion and gave a valuation for the teas as a whole. It is difficult therefore to guess the reasons for the differences in preference.

Further experiments on the effect of manuring have shown that when using a complete manure mixture of nitrogen, phosphoric acid and potash combined in the ratio of 2 : 1 : 1 in large quantities to supply 80 lbs. of nitrogen, 40 lbs. of phosphoric acid and 40 lbs. of potash or more it results in a loss in quality, but normal manuring with 40 lbs. of nitrogen and 20 lbs. of phosphoric acid and potash respectively does not show a loss in quality as compared with teas not manured. In this connection it is of interest to note that in no case does the delay in the application of half of the total dose of manure till after it is capable of becoming available during the second flush result in better second flush tea, nor does the application

of the manure in one dose in time to affect second flush quality appear to have exercised any effect either good or bad on the quality of the tea.

The effect of the manuring can be seen in the analyses of the leaf. Increasing quantities of the manure have resulted in increasing the quantities of caffein and non-caffein nitrogen, phosphoric acid and potash but in decreasing the amounts of tannin and total soluble solids.

In previous years attention has been called to the results of the experiment to ascertain the effect of the phosphoric acid upon the value of the tea made, and it has been shown over 3 years that there is a tendency which cannot be called significant to increase the value of the tea. It was therefore of interest to carry out a similar experiment on another garden situated on a heavier soil, in which case phosphoric acid was found to have no effect upon the value of the tea made.

Experiments also have been carried out upon the effect of drying temperatures upon the quality of tea made.

Tasters both in India and London agree in preferring teas fired at 175°F. and 190°F. as being preferable to those fired at 205°F. and these again are better than the teas fired at 220°F. The teas so made were stored for four months in glass bottles to ascertain whether any change took place during keeping. At the end of that time the low temperature fired teas were still preferred by tasters in India and the high fired least preferred. The touch of high fire on teas dried at 205°F. had apparently disappeared but the high fired character had not disappeared altogether from the teas dried at 220°F.

An interesting comparison is made between the tannin in tea and the tannin in Pan-supari consisting of Pan leaf and betelnut, Khoir (catechu), and lime. The ordinary khili pan weighs 5½ grammes and contains 0·84 grains of tannin. The ordinary moderate chewer takes about 20 khili pans a day thus consuming about 17 grains of tannin, the whole of which is normally swallowed. Addicts chew all day consuming 70 to 100 khili pans. A cup of tea contains about 3 grains of tannin. A normal tea drinker taking 5 to 6 cups daily therefore would consume about as much tannin as a moderate chewer of pan. This would seem to discount the statement that one factor which restricts the sale of tea in India is its tannin content which may prove harmful to the digestion.

Preparation of manure composts has been interesting many tea garden managers and we have been co-operating with them in analysing both the raw material and the finished composts.

ENTOMOLOGICAL.

The Entomological Branch has remained on a maintenance basis only and consequently investigation work has been impossible.

The collection has been maintained in good order and routine reports on specimens received have been issued.

The Insectary Assistant, Mr. M. Singha, toured in the Dooars during April.

MYCOLOGICAL.

During the year 1152 specimens were received and the proportion of the specimens under the various diseases is much the same as last year.

Black rot continued to cause serious loss on a number of gardens but in most areas it is found possible to control this blight without undue expenditure by treating each infected bush with 1% Burgundy Mixture as soon as it is found to be infected. On a few areas the conditions appear to favour the disease to such an extent that more costly methods are likely to be required.

Experiments have been carried out on various gardens for the control of Black rot. The results indicate that 1% Burgundy Mixture applied in April is more effective than Lime sulphur solution. In one case the Burgundy Mixture with adhesive was more effective than without the adhesive in giving a greater crop. This is thought to be due to the Burgundy Mixture with the adhesive controlling Red spider whereas Burgundy Mixture without adhesive has very little effect on the pest.

An experiment was carried out to ascertain the relative efficiency of different strengths of Burgundy Mixture. The use of 4% Burgundy Mixture in this case seemed to completely control the Black rot. The 1% and 2% solutions did not give complete control although they very greatly reduced the Black rot attack. In general it is probably most economic to use the 1% solution but for special cases it may be advisable to use the 4% solution.

The deaths of many bushes are associated with Sphaerostilbe repens (Violet root rot) on very stiff and Diplodia on very sandy soils. Both these fungi are very common in all tea soils in North East India. They attack plants weakened by other causes. With both these fungi lack of starch reserves seems to be the most common defect. This is associated with undue reduction in the leaf area remaining on the bush after plucking.

The reduction on leaf area may be due to plucking too hard or too premature leaf-fall induced by attacks of Red spider etc. Bushes growing on either of the class of soils mentioned are particularly subject to drought effects. It is of importance in dealing with bushes growing under these conditions to ensure ample effective leaf area below the plucking level and it seems that better results are obtained by leaving leaf between rounds of plucking than by leaving proportionately longer growtb before plucking commences.

The severity of Brown blight attack varies as the severity of the plucking. Longer initial growth and leaving leaves after tipping results in a lessening of the percentage of old leaves affected by Brown blight at the end of the season.

Manuring both at Tocklai and Tulsipara appears to have had no effect on the percentage of blighted to total leaves on the bush below the plucking level at the end of the season. Again it is to be noticed that the bushes at Tulsipara which received the larger quantity of nitrogen (80 lbs. per acre) have a smaller quantity of starch reserves than the bushes that received manure at the rate of 40 lbs. of nitrogen per acre or no manure.

Further experiments dealing with the control of Eelworm infection in nurseries less than 12 months of age have been carried out using calcium cyanamide at the rate of 12, 10 and 8 maunds per acre respectively, Neem cake at the rate of 25 mds. per acre, and a proprietary disinfectant, also hot water. None of the treatments had any appreciable effect upon the Eelworm infection, neither did the applications of Calcium cyanamide make any difference to the development of the plants.

In the course of a holiday the Mycologist took the opportunity of visiting the tea growing districts between Tamanthe and Homalin in the Upper Chindwin district of Burma. In this area the tea is grown for pickling, not for drinking purposes. The tea ordinarily in cultivation closely resembles the larger leaf Burma jat but there are a number of different types also present both in the cultivated and in the jungle areas. In the short time available only two types were collected, neither flowers nor seeds were available. The area in which the tea plant grows appears to be limited to the neighbourhood of Chindwin. Only one tea plant (probably introduced) was seen in the course of the journey through the mountains. The soil and type of jungle were such that it is unlikely that wild tea is present in the area or in the adjoining unadministered area round Sarameti. It is probable, however, that more wild tea would be found further up the Chindwin. The Vernay-Hopwood expedition whom the Mycologist met

at Homalin have found that in the case of certain mammals the Chindwin river itself formed a distinct boundary between two varieties of the same species. It seems worth while to ascertain whether the varieties of wild tea are divided similarly. Possibly a survey of this area would reveal a number of new varieties some of which may be valuable particularly in areas where a very cold weather is succeeded by a period of very heavy rain.

BACTERIOLOGICAL.

The colourless bacteria that have been found on tea leaf are not always of the same species and have been found to differ from factory to factory. These colourless bacteria are now differentiated into three types :—

(1) which occurs in considerable numbers on the fresh leaf and which is almost entirely destroyed during rolling since the uncoloured tannin of the fresh tea leaf appears to be toxic to these species.

(2) the second species of bacteria occur generally in smaller numbers on the fresh leaf and these again tend to be destroyed by the juice expressed during rolling.

(3) the third type which so far have only been found in smaller numbers are not destroyed by the tea juice but can develop rapidly in a factory and seem to be the same type as those which are responsible for producing dark colours and dull heavy liquors.

It is also noticed that on any particular tea shoot plucked only one of these three types occurred.

On fresh leaf that is allowed to remain wet a rapid development of bacteria takes place. The particular type developing being that above referred to as No. 3, whereas the type that is destroyed on rolling shows a much less rapid rate of increase. The species that are associated with the production of dull infusions are present in only small numbers on the fresh leaf. Under wet conditions these bacteria appear to be capable of outgrowing all other types present on the leaf.

During fermentation the bacterial numbers may decrease or show but little rate of increase after fermenting for 4 hours, and it would seem possible that working under satisfactory clean conditions fermented leaf should not contain more than 50,000 bacteria per gram of leaf which is much less than was previously thought to be possible. Whilst bacterial development can and does take place under unsatisfactory withering conditions it

would also appear that leaf may have a high bacterial count before it reaches the withering racks or chungs if it has been pressed down in the plucking baskets, when bacterial development is rapid. This leaf then spread on the withering chungs continues to show an increased bacterial development. It has long been known that leaf pressed down in the plucking baskets gives poorer quality tea and this has in the past been attributed to the rise in temperature. It would seem, however, that rise in temperature may not be the only factor concerned.

An investigation has shown that at Tocklai, leaf fired at a temperature of 180°F. is sterile after 15 minutes. This, however, does not represent the firing conditions that pertain in the bigger factories but serves to indicate that firing conditions can be so arranged as to give tea that is practically sterile at low firing temperatures.

BOTANICAL.

Regeneration is the formation of new growth in response to the stimulus given by the removal of pre-existing growth. It is impossible in practice to dissociate regeneration from flushing. Flushing is a natural (growth) response to environmental conditions whereas regeneration is flushing in response to the artificial conditions of a plucking stimulus.

The investigations in progress at Tocklai indicate that the exceedingly complex mat of minute regenerated shoots formed at the plucking surface in the course of a season is built up in an orderly fashion, the growth of the system being governed in the first place by the natural flush periods of the bush. It is also indicated that shoots plucked at any particular time come from a definite position on the branch system. There is thus indicated a difference in the nature of shoots removed from the plucking surface at different times.

The time of regeneration relative to a definite position of the flush period determines the nature of the subsequent growth. Delay in plucking results in the regeneration of shoots to reach a corresponding stage of development after a much shorter period of growth. This discovery indicates one of the factors which must affect the valuation of tea manufactured at different times.

The Botanist is of the opinion that the peculiar growth known as "Green fly stunt" is dependent in part at least on the coincidence of a plucking round with a critical change in the metabolism of the bush, and it

is suggested that the sporadic occurrence of "Green fly stunt" depends on how far the effect of the plucking round happens to be in or out of step with the cycle of changes going on in the plant.

It has already been shown that there is a periodicity of crop production corresponding with the natural flush periods of the bush.

It has also been shown that the hairiness of a leaf also fluctuates with the natural flush periods of the bush and there is evidence for associating fluctuations in quality with fluctuations in hairiness. There is however also the valuation associated with the absolute hairiness between jats. The available data that we have obtained shows that the jat with the highest valuation is also the one associated with the higher degree of hairiness. There is a very considerable difference between the hairiness of different jats of tea and the relative hairiness has been determined throughout the past year for 3 different varieties. The fluctuations in hairiness that occur throughout a season for the different jats may be at different times, for instance Kalline and Tingamira have shown the same time of fluctuation in hairiness whereas Betjan has shown a different time. This difference may however be seasonal and needs further study.

Work has been continuing in regard to variety selection. Considerable differences are to be observed as for instance that some varieties do not have a banjhi period as do other varieties.

AGRICULTURAL.

Towards the end of the year, 10 acres of new tea were planted and a further 6 acres is being cleared, fenced and levelled and nurseries prepared for planting in 1936 in accordance with the permission obtained from the Tea Licensing Committee.

The amount of leaf sold amounts to—

2,561 mds. at Rs. 1-8-0 per maund, and
220 mds. at Rs. 1-0-0 per maund.

Export Quota rights have been sold (less brokerage)

at Re. 0-3-9 per lb. for 28,440 lbs.	...	Rs.	6,598	15 6
at Re. 0-3-3 per lb. for 5,801 lbs.	...	Rs.	1,166	8 9

Manufacturing Rights have been sold (less brokerage)

at Re. 0-2-1 per lb. for 35,269 lbs.	...	Rs.	4,509	14 0
at Re. 0-2-0 per lb. for 5,801 lbs.	...	Rs.	711	14 0

Various areas at Tocklai are now giving a steady crop which is considered to vary only under seasonal influence. This shows a 5 per cent. decrease in crop this year compared with 1934.

The manuring experiments which have now been continued for sixteen years show that the green cuttings of Boga medeloa (Tephrosia candida) have the same efficiency as a manure, when buried as they are cut, as Sulphate of ammonia. This is of interest as showing that such material does not appear to be in need of any preparation such as composting before using as a manure. Horn meal which is regarded in Great Britain as a slow-acting manure seems to be nearly as efficient as Sulphate of ammonia. It is probable that the somewhat greater efficiency of Sulphate of ammonia may be connected with the increase in the soil acidity brought about by the continual use of this manure. It is of interest to note that the continual use of this manure over a period of sixteen years still shows it to be the most satisfactory nitrogenous manure, and the manufacturing experiments have shown that tasters both in India and London are unable to differentiate between the teas made from areas receiving organic or inorganic manures. It is of considerable importance to note that the experiments to ascertain the effect of different levels of nitrogen manuring have shown that the increase of crop is proportional to the increase in the nitrogen added to the soil.

In 1935

40 lbs. of nitrogen has increased a crop over the unmanured plots by ... ... 3·82 mds. per acre.

80 lbs. of nitrogen has increased a crop over the unmanured plots by ... ... 8·2 mds. per acre.

120 lbs. of nitrogen has increased a crop over the unmanured plots by ... ... 11·41 mds. per acre.

The effect of continuous manuring is cumulative. The effects becoming larger as the size of the bush increases until a roughly constant increase is maintained so long as the same dose of nitrogen is applied annually.

The experiments started in 1931 to determine the value of cattle manure shows that the 20 tons per acre applied in 1931 has exerted a crop effect until the end of July 1935 since when the crop has been the same as from the unmanured area. Over the five years the 20 tons of cattle manure containing 120 lbs. of nitrogen has produced 6·8 mds. of tea. This is about half what would have been expected by the use of 120 lbs. nitrogen as Sulphate of ammonia during the same period of time.

In 1935 an experiment was started to ascertain the manurial value of tea prunings. The area was giving approximately 10 mds. per acre and the prunings amounted to 1·5 tons of dry matter per acre containing 60 lbs. of nitrogen. The manurial effect has been to produce an increase of crop of about one-third of what would have been obtained by the use of 40 lbs. of nitrogen per acre as Sulphate of ammonia (200 lbs.). Such an annual addition of organic matter is a considerable factor in maintaining the organic matter content of the soil and perhaps explains the failure to get results on tea from the addition of still further organic matter apart from the value of the nitrogen so added.

Cultivation continues to indicate that suppression of weed growth and not soil stirring is the important factor. This led to an experiment to ascertain whether it was necessary to hoe in the manure or whether it might be left to remain on the surface. One year's experiment has given the result that there is no difference in crop whether the soluble nitrogenous manure (Sulphate of ammonia) is hoed into the soil or left on the surface.

The plucking experiment shows very clearly that superfine plucking to 1 leaf and a bud and 2 leaves and a bud and single banjhies only, gives no smaller crop than fine plucking to 2 leaves and a bud and single banjhies whether broken back to the janum or to the tipping level or not broken back at all. When banjhi shoots are not plucked a considerable loss in crop takes place. Plucking to 2 leaves and a bud and soft double banjhies also gives no significant increase in crop nor does it show any significant decrease in the quality of the tea. Coarse plucking taking everything that is grown in seven days down to the janum does give a considerably increased crop and at the same time a considerably decreased value of the tea. The plucking throughout the whole of this experiment is done at 7-day intervals.

Experiments comparing collar pruning with medium pruning to 18 inches which was carried out in the cold weather 1927-28 still shows a considerable difference in crop between the two methods of pruning. In 1935

Medium pruning has given a crop of 15·39 mds. per acre

Collar pruning has given a crop of 13·73 mds. per acre

in the eighth year after the pruning.

P. H. CARPENTER,

Chief Scientific Officer.

S. P. W.—3416—18-3-36—1,100.